Appendix X
Bunker Creek Study:
Hydrologic and Hydraulic Models for the Bunker Creek System in Kellogg, Idaho

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Prepared for:
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Acronyms & Abbreviations

Box	Original 21-square miles designated as the Bunker Hill Superfund Site
cfs	Cubic feet per second
CIA	Central Impoundment Area
CTP	Central Treatment Plant
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
GPS	Global Positioning System
HEC or HEC-1	Hydrologic Engineering Center of the U.S. Army Corps of Engineers
HEC-HMS	HEC-Hydrologic Modeling System
HEC-RAS	HEC-River Analysis System
I-90	Interstate-90
mgd	Million gallons per day
NRCS	National Resource Conservation Service
OU2	Operable Unit 2 (Non-Populated Areas) of the Bunker Hill Superfund Site
ROD	Record of Decision
SCS	Soil Conservation Service
SFCDR	South Fork Coeur d’Alene River
SPA	Slag Pile Area
SWM	Stormwater Management
UPRR	Union Pacific Railroad

SECTION 1.0 INTRODUCTION

The purposes of this report are to determine the capacity of Bunker Creek and provide solutions to mitigate possible flooding and negative water quality impacts. The Bunker Creek Study specifically modeled the hydrologic impacts of the contributing watersheds to Bunker Creek as well as the hydraulic capacity of Bunker Creek itself. These models were constructed for several scenarios that were determined to be significant including past, present, and future.

This modeling effort was requested by the Idaho Department of Environmental Quality due to several factors which have changed the conditions of Bunker Creek and surrounding areas since they were last studied in early 1996. Some of these factors include:

- Current channel geometry of Bunker Creek is unknown due to complications during re-construction of the channel in late 1996 and 1997.
- Hillside vegetation and local development on the surrounding hillsides have changed resulting in a change in rainfall runoff potential.
- Significant yard and common use area remediation has occurred around Bunker Creek and an inherent flooding risk to this remedy is present.
- The Federal Emergency Management Agency (FEMA) currently has a pending floodway designation of the Bunker Creek corridor.

This report will specifically discuss the background, inputs, assumptions, models, results, alternative analysis and recommendations that were conducted for the Bunker Creek system.

SECTION 2.0 BACKGROUND

Bunker Creek and the surrounding areas have a long, complex, and historical record. Based on historical maps and photographs from the early 1900s, the South Fork Coeur d'Alene River (SFCDR) was approximately located in the area that is now occupied by Bunker Creek. It is also believed that due to mining activities in the early 1900s, the SFCDR alignment was moved to the north side of the valley, where it resides today. By the 1930s, a natural wetland/drainage channel had formed in the vacated area, which remained for several decades. Degradation of this drainage area occurred due to extensive dumping of mine tailings and waste rock, sedimentation, and other human activities. Local flooding and drainage issues quickly arose for Bunker Creek and the surrounding areas. Up until 1996, Bunker Creek served primarily as a small conveyance ditch for the Central Treatment Plant (CTP) which discharged into the SFCDR through a culvert under Interstate-90 (I-90).

Bunker Creek is located in Operable Unit 2 (OU2), the Non-Populated Areas, of the Bunker Hill Mining and Metallurgical Complex Superfund Site in an area commonly referred to as the Bunker Hill Box (Box). In 1992, the Environmental Protection Agency (EPA) presented a Record of Decision (ROD) for OU2 (EPA 1992) in which the Bunker Creek remedial action was addressed. The ROD stated that Bunker Creek was to be channelized and lined in order to properly address the conveyance and water quality issues. Between 1996 and 1997, approximately 7,600 linear feet of Bunker Creek was re-constructed as outlined by EPA and the State of Idaho. The new channel included a rock-lined low flow channel as well as a seeded and planted floodplain. Due to unforeseen complications, Bunker Creek was not constructed exactly as the design had specified and, therefore, the alignment and profile of the channel were not documented specifically (CH2M Hill 2005).

SECTION 3.0 SCOPE OF WORK

This section describes in detail the scope of work for the Bunker Creek study. This study included several major components including the analysis of Bunker Creek and the surrounding hillsides for past, present, and future conditions. This analysis was conducted using a hydrologic model of the contributing watersheds and a hydraulic model of the Bunker Creek channel. The study also developed and evaluated alternatives for mitigation based on the specific results of the modeling conditions and recommends solutions and associated relative costs for mitigation for the flooding and water quality concerns for Bunker Creek.

3.1 Analyze Bunker Creek for Several Conditions

The analysis of Bunker Creek included both hydrologic and hydraulic conditions. First, the surrounding areas were analyzed for their hydrologic condition and the contributing watersheds to Bunker Creek were delineated. These watersheds included several hillside gulches, the CTP, Central Impoundment Area (CIA) and a portion of the City of Kellogg.

In order to capture all necessary conditions as they relate to Bunker Creek, several scenarios were generated and analyzed. These conditions show the changes in the local contributing watersheds as well as the Bunker Creek channel itself, if any. It is important to note that this entire modeling and analysis effort was based primarily on a 100-year, 24-hour duration storm event for Kellogg, Idaho. Lesser flows were considered only to see what the existing channel will convey. The following text describes each scenario used in the models.

3.1.1 1996 Condition

The first condition is based on the design parameters used for the construction of Bunker Creek and will be referred to as the “1996 condition”. Due to lack of data and construction complications, no as-built information is available for Bunker Creek. As a result of this lack of data, this modeling condition was not completed or analyzed.

3.1.2 2007 Condition

The existing condition or “2007 condition” is the state of Bunker Creek and the contributing watersheds as they were in 2007. Extensive field data were collected to incorporate all necessary information as inputs for both the hydrologic and hydraulic models. The information was gathered using survey-grade Global Positioning System (GPS) and total station survey, field photos, site visits, and geospatial data information as needed. The physical characterization of the local hillsides and channel geometry was determined to be vital for accurate and realistic models.

3.1.3 Design Condition

The purpose of the “design condition” is to portray the development of Kellogg and the surrounding areas in an accurate and realistic future condition. Kellogg is currently undergoing an expansion due to development of the Silver Mountain Ski Resort as well as several local tourist attractions. Future development could have a significant impact on

Bunker Creek and the surrounding areas. This report will specifically outline the criteria and methodology used to generate this condition.

3.1.4 Ultimate Build-Out Condition

The “Ultimate Build-out” condition will include the future development of Kellogg and surrounding areas to the maximum as allowed by land use regulations and physical constraints. This condition looks at several factors as they relate to the overall maximum development as allowed in the area. There is no specific timeframe associated with this condition. The intention of this condition is to portray the maximum effects of development that could be seen on the Bunker Creek system. There are several factors that contributed to the development of this condition including the City of Kellogg Comprehensive Plan (City of Kellogg, unknown), local population growth factors, City and County development standards and related information. No determination of feasibility for this condition was developed, but an extreme case scenario was developed for a comparative analysis.

3.2 Develop and Evaluate Alternatives for Mitigation

After the modeling for all the conditions outlined above was completed, results from the models were analyzed. As flooding issues were presented, developments of alternatives for mitigation were compiled. Due to the uncertainty of the Bunker Creek system, mitigation alternatives were not generated until model results were analyzed. The criteria by which the alternatives were selected and evaluated were developed as the project developed. Possible categories for these alternatives included administrative, structural, or a combination of each type.

3.3 Recommend Solutions and Cost Estimates

After alternatives were selected and analyzed based upon the future conditions of the Bunker Creek system, recommendations were made for flooding mitigation. The specific recommendations are discussed in further detail later in the report. Relative costs for each recommended alternatives were developed in order to quantify the cost of the action versus effectiveness. This should help aid any future decisions that will be made regarding the Bunker Creek system.

SECTION 4.0 REVIEW OF SUPPORTING INFORMATION

Prior to any modeling effort taking place on the Bunker Creek system, a significant amount of research was completed to ensure all applicable documentation and information were used. The following section outlines the documentation and information gathered regarding Bunker Creek and its contributing watershed.

4.1 Past Studies

Bunker Creek is an important part of the drainage system for portions of Kellogg and the surrounding hillside gulches. Multiple documents have been compiled on a wide variety of topics including remedial actions, historical background information, flood conveyance capacity, and water quality monitoring along with several others. The main documents used for the primary research, modeling, and analysis are listed below along with a brief summary of the information used from each document. Refer to the reference section for a complete list of documents.

4.1.1 Basis for Hydrologic Calculation for Gulches, Bunker Hill TM, 1995

This technical memorandum specifically discusses and outlines the assumptions, calculations, analyses, and information to be used when performing hydrologic calculations for the Gulches and areas inside Bunker Hill (Sundgren 1995). This document was used as the starting point and basis for many assumptions, analyses and calculations performed for this study.

4.1.2 Bunker Creek Hydrology Report, 1996

The flood hydrology for the Bunker Creek system was initially modeled in 1996 and results documented by Spectrum in the “Bunker Creek and Government Gulch Flood Hydrology” report (1996). In this document, results from a HEC-1 hydrologic model are reported and summarized for the Bunker Creek and Government Gulch systems. The capacity of Bunker Creek at that time is also discussed as well as the preliminary design for the re-construction of Bunker Creek. This report has been used by stakeholders for reference to the current condition and flow rates for Bunker Creek until the present. An update to this report and hydrology information is one of the goals of the current study.

4.1.3 Bunker Creek Design, 1996

The Bunker Creek Design Report (CH2M Hill 1996) outlines the parameters and calculations used in the design of Bunker Creek for the re-construction of the channel. This document was a direct outcome of the 1992 ROD (USEPA 1992) which stated that the Bunker Creek channel needed to be re-constructed to increase conveyance capacity and water quality. This document was used as a reference for information to assist in gaining accurate knowledge of the intended design and channel configuration for the Bunker Creek channel.

4.1.4 CIA Stormwater Management TM, 1998 & As-Built Drawings

The purpose of this memorandum was to outline the design for the stormwater management (SWM) system for the CIA (CH2M Hill 1998). This memo specifically outlines the assumptions, design parameters and system design for the CIA SWM system. The stormwater system was designed using the 100-year, 24-hour storm event. A value of 1.75 cubic feet per second (cfs) per acre is noted as the runoff value used for design calculations. The area of runoff used for the CIA area was calculated based on the as-built drawings provided by CH2M Hill upon the completion of the CIA and SWM system.

4.1.5 5-year Reviews, 2000 & 2005

The EPA conducts reviews of the Bunker Hill Superfund Site every 5 years to assess the progress of work and remedial actions completed (EPA 2000, 2005). These documents were used as background information sources and progress reports for Bunker Creek and the surrounding areas for the tasks that have been completed to date as well as any future plans for these areas.

4.1.6 FEMA Flood Insurance Study for the City of Kellogg, 2005

A preliminary Flood Insurance Study (FIS) for the City of Kellogg was published on July 15, 2005 (FEMA 2005). This study was conducted as an update to the previous FIS conducted in 1979. This document specifically looked at the flooding potential of the SFCDR in the City of Kellogg. In this preliminary study, the current levee system through Kellogg is considered to be non-certified; therefore, the model does not include these levees. As a result, a new floodway is designated along Bunker Creek. This modeling scenario could have a significant impact on the capacity of Bunker Creek as well as the future construction and development of the surrounding areas.

4.2 Important Facts/Information

In addition to the above references, there is a significant amount of information that is known about Bunker Creek but is not necessarily delineated in the documents previously discussed. This information is key to the analysis of Bunker Creek and the surrounding watersheds in order to portray the most accurate situation possible.

Since 1996, several things have changed which have direct effects on the Bunker Creek channel and its conveyance capacity. First, the CIA and Union Pacific Railroad (UPRR) Trail limit the physical extents in which Bunker Creek can be located. The CIA is located directly to the north of Bunker Creek and the UPRR Trail is directly south. Second, four sets of culverts have been installed in Bunker Creek, which are not included in either the 1996 design (CH2M Hill 1996) or the current FEMA model (FEMA 2005). Third, a portion of the City of Kellogg's storm sewer system discharges into the upper reaches of Bunker Creek (Sharpe 2007). Lastly, future developments for Kellogg and the surrounding areas are anticipated to discharge runoff to Bunker Creek. This study incorporates these changes in the Bunker Creek system (Bourque 2007, Zilka 2007).

SECTION 5.0 HYDROLOGIC MODEL

In order to model the Bunker Creek system in its current condition, a hydrologic model of the Bunker Creek watershed was developed. The hydrologic model was used to model the 100-year, 24-hour duration precipitation event only. The 100-year return interval storm event is considered the design standard for engineering design in which protection of the remedy and flooding risk is of concern. Specific details about the modeling methodology, inputs, assumptions, modeling scenarios and results are discussed below.

5.1 Modeling methodology

The hydrologic model was developed for the Bunker Creek watershed in order to completely understand the relationship between the hillside gulches and the Bunker Creek channel. The modeling program used was the Hydrologic Engineering Center Hydrologic Modeling System commonly referred to as HEC-HMS. Refer to Figure 1 for a diagrammatic view of the watershed layout used.

First, all available, applicable, and relevant data for the area of Kellogg and its surrounding hillsides were compiled. Next, these data were used to develop weighted curve numbers for each sub-watershed. Additional input parameters that were required for the hydrologic model were also calculated and/or compiled such as the time of concentration and routing parameters. Refer to Appendix A for a complete list of the calculations and inputs used for the hydrologic model. Further details regarding the models, inputs, assumptions, data used, and methodologies for each model are discussed below in detail.

5.1.1 Use of GIS for Data Compilation

In order to represent the Bunker Creek watershed as accurately as possible, many sources of data and information for the region were compiled, mapped, and analyzed. The information used was obtained from several different sources and has not been independently verified.

The main data layers used in this analysis include:

USGS Digital Terrain Models. Ten Meter Digital Elevation Models provided by the Natural Resource Conservation Service, USDA.

SURDEX Aerial Photography. 2006. USDA Farm Service Agency, natural color aerial photography (National Agriculture Inventory Program) at 1 meter resolution.

National Land Cover Dataset. 2001. Multi-Resolution Land Characteristics Consortium. (http://www.mrlc.gov/mrlc2k.asp). Data layers include: Land Cover, Canopy Closure, Impervious Percent.

Derivative data include slope and aspect derived from the Digital Elevation Model. All data and associated mapping are presented in the North American Datum of 1983 (NAD83) in meters for UTM Zone 11N. Metadata for all layers is available upon request from TerraGraphics. Soil type, vegetation and municipal zoning derived from these GIS sources are shown in Figure 2, Figure 3, and Figure 4, respectively.

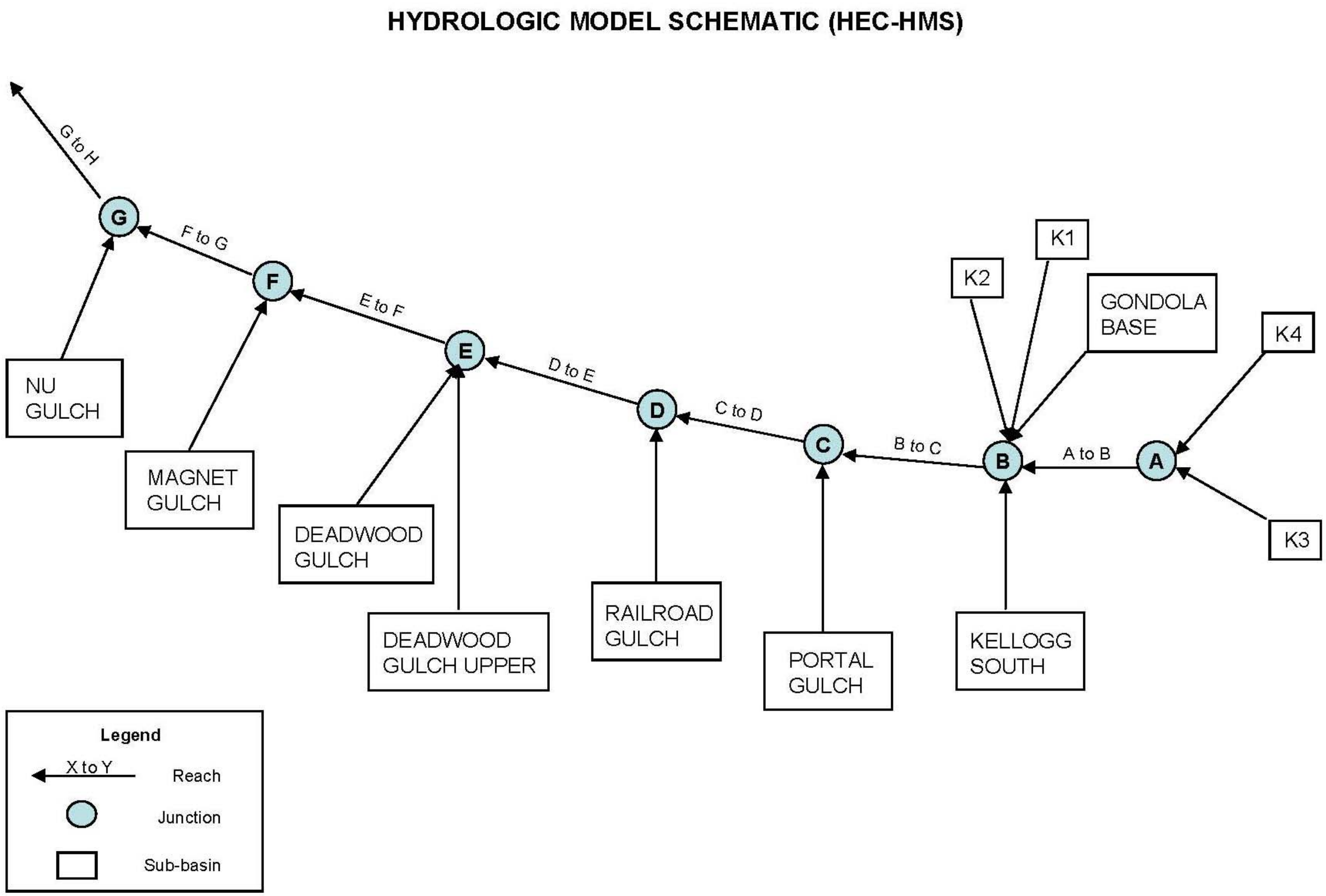
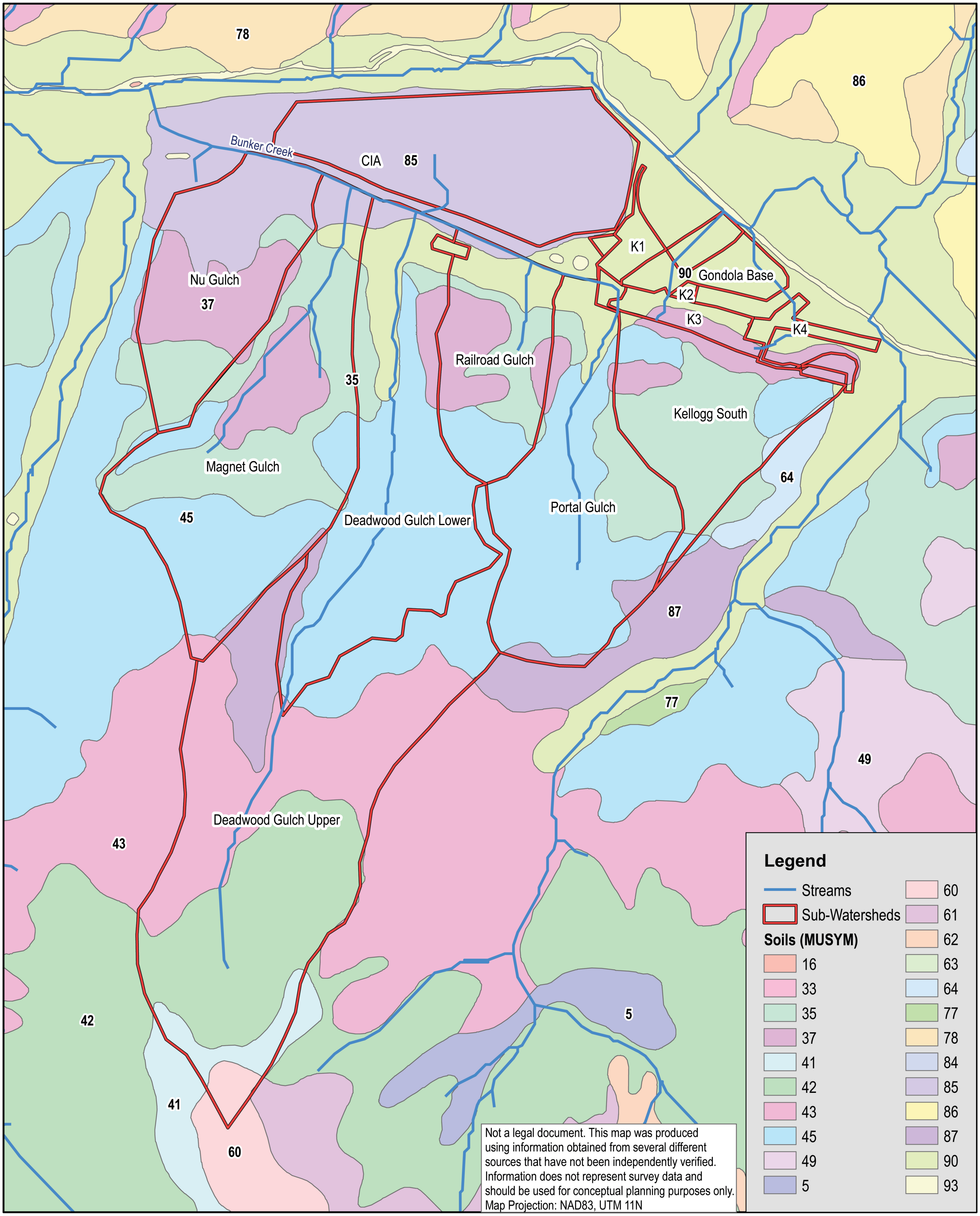


Figure 1 Hydrologic Model Schematic (HEC-HMS)



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FILE Idaho/Clients/BCreek_A2.MXD
PRINT DATE June 6, 2008
PROJECT NUMBER 2005:3160-80

Figure 2
Bunker Creek
Soils

1 inch equals 2,000 feet
0 1,000 2,000 Feet

N

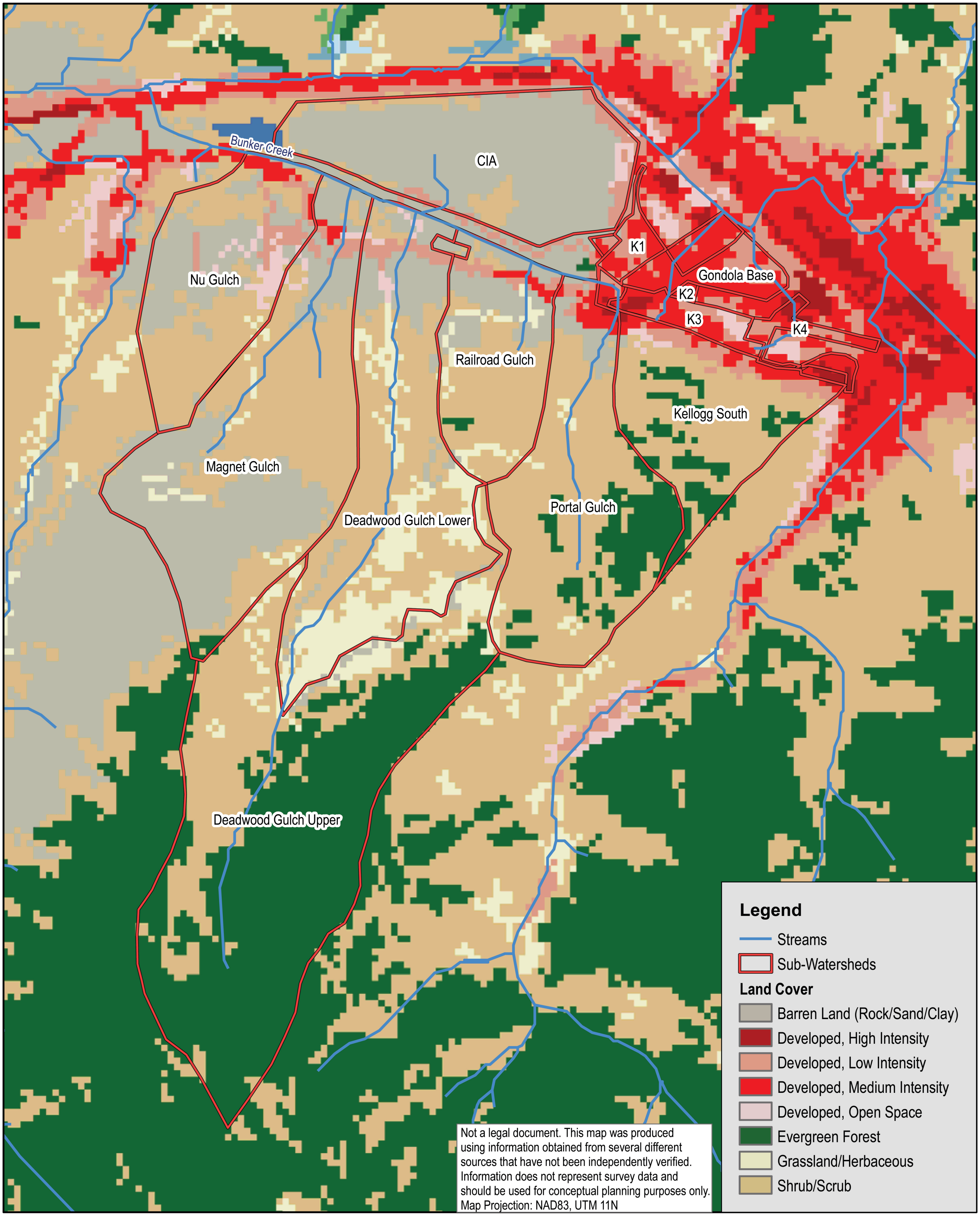

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Figure 3
Bunker Creek
Vegetation

1 inch equals 2,000 feet
0 1,000 2,000 Feet
N

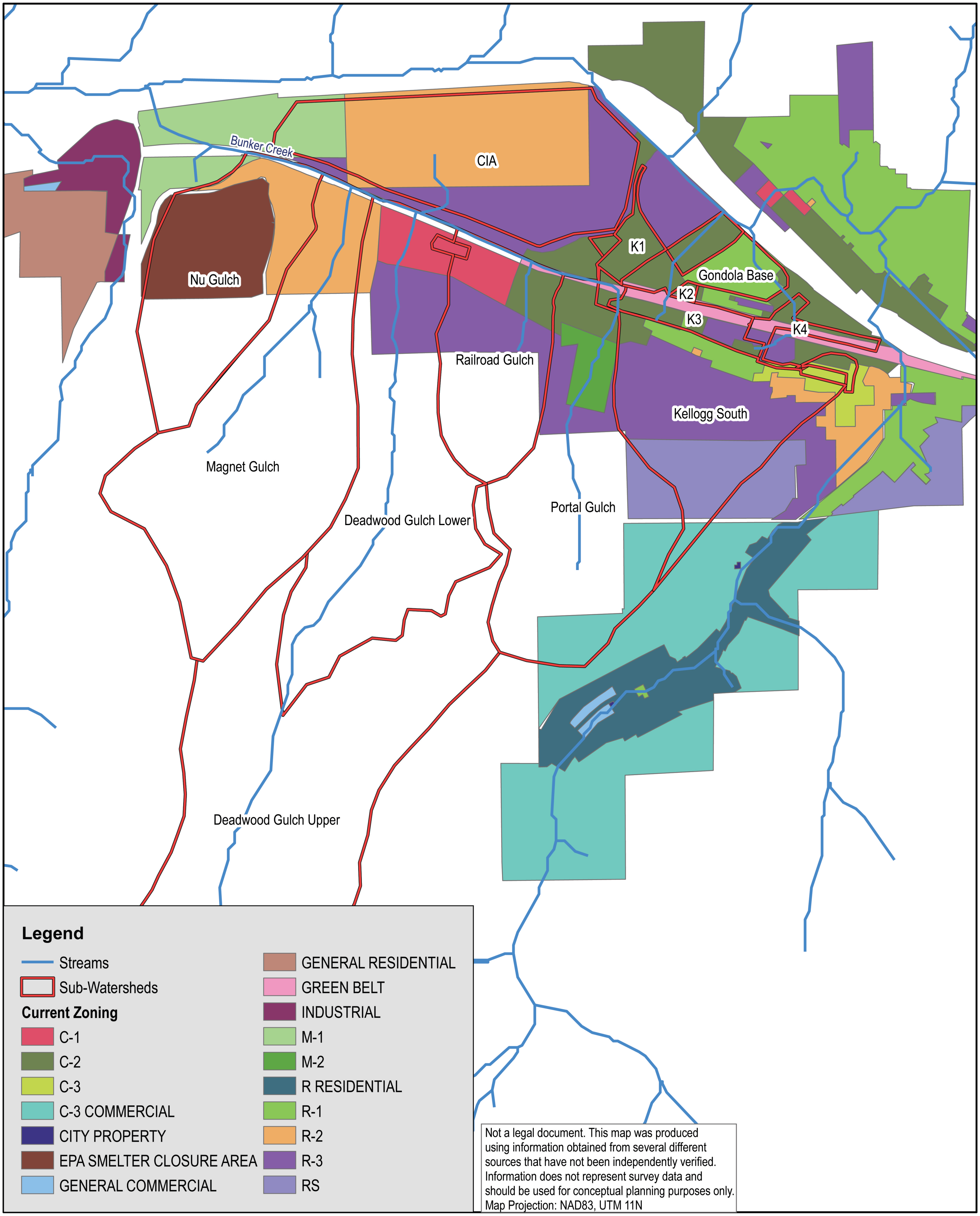

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Figure 4
Bunker Creek
Municipal Zoning

5.1.2 SCS Runoff Curve Number Methodology

As part of the hydrologic modeling process, runoff curve numbers were used for a representation of the amount of water that would run off a specified area. This specific methodology was developed by the Soil Conservation Service (SCS) and has been accepted as a standard engineering methodology. The SCS runoff curve number methodology is a function of three variables including soil group, land use, and land treatment class.

5.1.2.1 Soil Group

The soil hydrologic group classification is broken into four groups labeled A, B, C, D and is based on the soil's potential runoff interpreted by physical soil characteristics. The specific soil group classifications for the Bunker Creek watershed were taken from the local Natural Resources Conservation Service (NRCS) soil survey (Weisel 2002). This survey provided group letter label classification as well as physical characteristics for each soil type found in the area. From this soil survey, it was found that the soil type "slickens" was not classified into a specific hydrologic soil group by the NRCS. Spectrum (1995) classified "slickens" soil type to a soil group C. For consistency purposes, this same classification was used in this analysis as well. Refer to Table 1 for a complete list of soil names, types, and map number used for the analysis.

Table 1 Soil Types for Bunker Creek Watershed

Soil Name	Soil Name (Abbreviated)	Map #	Soil Group
Hobo silt loam, very strong acid, eroded	Hobo silt loam	35	D
Hobo-Helmer silt loam, extremely acid, severely eroded	Hobo-Helmer silt loam, severely eroded	37	D
Honeyjones-Ahrs association, 15 to 35 percent slopes	Honeyjones-Ahrs association	41	B
Honeyjones-Ahrs association, 35 to 75 percent slopes	Honeyjones-Ahrs association	42	B
Honeyjones-Ahrs association, moderately acid	Honeyjones-Ahrs association	43	B
Hugus gravelly loam, very strongly acid, severely eroded	Hugus gravelly loam, severely eroded	45	B
Latour gravelly silt loam, 15 to 35 percent slopes	Latour gravelly silt loam	60	B
Latour gravelly silt loam, 35 to 75 percent slopes	Latour gravelly silt loam	61	B
Lotuspoint, very strongly acid-Rock outcrop complex, eroded	Lotuspoint, eroded	64	C
Slickens	Slickens	85	C
Tigley family extremely gravelly loam, extremely acid, gulled	Tigley family, gulled	87	B
Udarents-Aquic Udifluvents-Slickens complex	Udarents-Aquic	90	C

5.1.2.2 Land Use

The land use classifications were compiled using cover type and percent cover as given in the National Land Cover Dataset. The Bunker Creek watershed was broken into sub-areas which had similar characteristics of cover type, soil type, and percent cover. Due to the different classifications between the National Land Cover Database and the SCS methodology, some interpretation was conducted to compile a consistent family of land use classifications. Refer to Table 2 for a complete listing of land use conversions between the national database and SCS methodology.

5.1.2.3 Land Treatment

The land treatment or soil condition is a generic classification of good, fair, or poor which is based mainly on percent cover. This information was compiled through the National Land Cover Database. Refer to Table 3 for the complete breakdown of this classification. It is important to note that land treatment conditions differ slightly based upon land use classifications.

5.1.2.4 Development of Weighted Curve Numbers

Several factors were important when compiling this family of conversions and analyses. The first consideration was the technical memo regarding hydrologic calculations for Gulches in Bunker Hill (Sundgren 1995). This memo specifically listed the land use, hydrologic soil group, and condition along with the associated curve numbers. The second consideration was the soil type and soil condition for each sub-area. After compiling all the sources, information and assumptions, each sub-area of the Bunker Creek watershed could be assigned its associated curve number. A complete listing of the curve numbers referenced, based on land use, is listed in Table 4.

Table 2 Cover Type to Land Use Conversions

Cover Type	Land Use
Shrub/Scrub	Range
Evergreen Forest	Woods
Barren Land (Rock/Sand/Clay)	Non-cultivated Land
Grassland/Herbaceous	Meadow
Developed, Low Intensity	Residential
Developed, Medium Intensity	Industrial
Developed, High Intensity	Commercial

Table 3 Hydrologic Soil Condition Classifications

Condition	% Ground Cover		
	Forest - Range	Non-cultivated Agriculture	All others
Poor	< 30	< 25	< 50
Fair	30 - 70	25 - 50	50 - 75
Good	> 70	> 50	> 75

Table 4 SCS Curve Numbers by Land Use and Soil Group

Land Use	Hydrologic Soil Group			
	A	B	C	D
Woods - Poor	45	66	77	83
Woods - Fair	36	60	73	79
Woods - Good	30	55	70	77
Range - Poor	68	79	86	89
Range - Fair	49	69	79	84
Non-cultivated Land - Poor	68	79	86	89
Meadow	30	58	71	78
Residential	77	85	90	92
Industrial	81	88	91	93
Commercial	89	92	94	95
Paved Areas	98	98	98	98

Upon generation of curve numbers for the Bunker Creek watershed, there were a few discrepancies between the agreed upon standard for Sundgren (1995), Spectrum (1996) and standard SCS methodology (McCuen 2005). First, the curve number for Woods in good condition has a different assigned value between the Published SCS table and Sundgren (1995). In order to stay consistent and for a more conservative approach, the higher number from Sundgren (1995) was used for this analysis. Second, it was noted that the curve numbers used for the hydrologic analysis done by Spectrum used different values than were reported Sundgren (1995). This inconsistency will directly affect the ability to compare and correlate the runoff results between Spectrum (1996) and the current modeling effort. Lastly, Sundgren (1995) lists basic land uses and does not include an all-inclusive list for the known land uses. Therefore, curve numbers for areas in the City of Kellogg were developed based upon percent impervious data given by the National Land Use Database as well as a "weighted curve number" equation (McCuen 2005). For future development projections, the Kellogg development standards, as printed in Kellogg's Comprehensive Plan (unknown), were used based on zoned land use. Refer to Table 5 for a summary of all the calculated weighted curve numbers for all modeling conditions.

Table 5 Calculated Weighted Curve Number by Area

Area	Modeling Condition		
	2007	Design	Buildout
Deadwood Lower	81.3	73	73.5
Deadwood Upper	64.3	56.1	56.1
Gondola Base	93	93	93
K1	91	91	91
K2	91	91	91
K3	91.9	92.3	92.8
K4	91.8	91.3	91.3
Kellogg South	87.4	86.3	88.4
Magnet Gulch	84.8	79.2	79.6
NU Gulch	87.7	83.4	83.3
Portal Gulch	80.1	73.7	80.9
Railroad Gulch	86.3	81.1	82
CIA/SPA	N/A	N/A	91.5

5.1.3 HEC-1 to HEC-HMS

The hydrologic modeling program used by Spectrum (1996) was developed by The Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers and is commonly referred to as HEC-1. Since that time, HEC has developed an updated program referred to as HEC Hydrologic Modeling System (HEC-HMS). As part of the model update, the data used as reference, developed by Spectrum, was converted to a format that could be read by HEC-HMS using the convert function of HEC-HMS. The basic methodologies and analyses remained relatively consistent between the two programs so comparison of the two models is possible but not an exact correlation due to upgrades in HEC-HMS.

5.2 Major Model Inputs

To model the Bunker Creek watershed hydrology, it was necessary to identify all major runoff areas and sources. The runoff into Bunker Creek is mainly comprised of hillside gulches, the City of Kellogg stormsewer, the CTP outfall, and stormwater from the CIA.

The majority of runoff contributions came from the steep hillside gulches to the south of Bunker Creek along its entire length: Kellogg South, Portal Gulch, Railroad Gulch, Deadwood Gulch, Magnet Gulch, and NU Gulch. Refer to Figure 5 for the geographic locations of these gulches and their relationships to Bunker Creek.

The remaining areas that contribute runoff into Bunker Creek are primarily within the City of Kellogg. Portions of the City of Kellogg have stormsewer networks that collect stormwater runoff from the city and pipe it into Bunker Creek. In order to model as accurately as possible, portions of the city were divided into sub-areas of similar land uses and stormwater systems. In addition to the City of Kellogg, there is contributing flow from runoff from the CIA and outfall from the CTP. In the Spring 2008, the CTP was observed to produce a flow ranging from 2-4 million gallons per day (mgd) with a maximum capacity of approximately 6 mgd (10 cfs). As a more conservative approach, a constant flow of approximately 10 cfs was used for all modeling conditions.

The last possibility for flooding contribution on Bunker Creek is the floodway designation proposed by FEMA (2005). Due to non-certified levees on the SFCDR though Kellogg, FEMA has designated a floodway through a portion of Kellogg just to the east of the CIA and into Bunker Creek. Flood water from the SFCDR is shown to flow out of the river and through Bunker Creek. This flood water will significantly increase the flow through Bunker Creek. Refer to Appendix A for the preliminary floodplain map produced by FEMA (2005). However, further analysis completed by TerraGraphics determined the top elevation of the Kellogg levees to be higher than the 100-year water surface elevation of the SFCDR as shown by FEMA. Therefore, no specific effects from this designation were used in the updated Bunker Creek model.

The other major model input included the precipitation depths for the area of concern. A family of Duration, Frequency, and Depths has previously been developed for Kellogg (in the Comprehensive Plan) and was used for this model as well. Table 6 displays the entire family of values for the City of Kellogg.

Table 6 Precipitation Depths (inches) for City of Kellogg

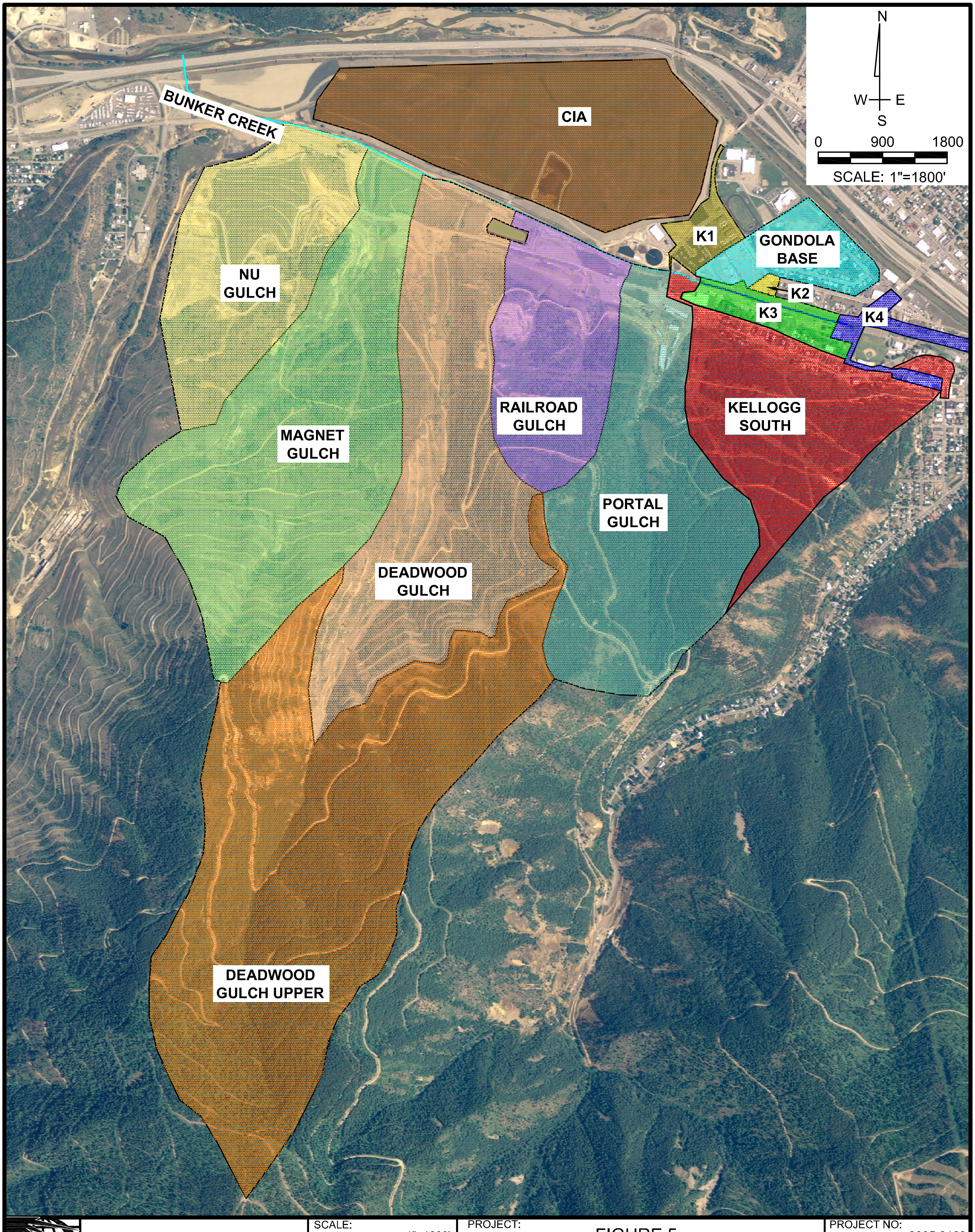
Return Period (years)	Duration							
	15-min	**30-min**	**1-hr**	**2-hr**	**3-hr**	**6-hr**	**12-hr**	**24-hr**
2	0.23	0.32	0.41	0.54	0.66	0.95	1.38	1.80
5	0.32	0.44	0.56	0.70	0.83	1.15	1.68	2.20
10	0.38	0.53	0.67	0.84	0.99	1.35	1.98	2.60
25	0.47	0.64	0.82	1.00	1.16	1.55	2.28	3.00
50	0.53	0.73	0.93	1.13	1.31	1.75	2.58	3.40
100	0.59	0.82	1.04	1.27	1.47	1.95	2.88	3.80

5.3 Assumptions

All the methodologies and modeling processes used for this study have assumptions and limitations associated with them. This section is not intended to be all inclusive but just to highlight a few main assumptions and limitations found during the modeling process. Most of the limitations, boundary conditions and assumptions listed below can be further referenced in USACE, 2008.

5.3.1 Model Assumptions

The purpose of the HEC-HMS model is to estimate hydrologic peak flows based upon watershed conditions. For detailed description of the assumptions and limitations associated with the HEC-HMS program, refer to the HEC-HMS User Manual version 3.2 (USACE 2008).



TerraGraphics Environmental Engineering, Inc.	SCALE: 1"=1800'	PROJECT: FIGURE 5 BUNKER CREEK WATERSHED AREAS	PROJECT NO: 2005-3160
	DRAWN BY: A. HEITMANN		DATE: 05/28/08
	ENGINEER: A. HEITMANN		SHEET: 1 OF 1

5.3.2 Input Assumptions

This section will discuss the major input assumptions that were used while compiling the data for the hydrologic model. This list is not intended to be all-inclusive but to capture the major input assumptions, which are listed in no particular order.

- The west end of the CIA is commonly referred to as the Slag Pile Area (SPA). This area was not included in the existing hydrologic model due to its flat slope and mostly gravel surface. It was determined that no significant runoff would be contributed to Bunker Creek from this area prior to future development.
- The information presented and used for the existing Kellogg storm sewer system was based upon a field visit with Jaime Sharpe with the Public Works Department for the City of Kellogg.
- Lag time calculations used the methodologies outlined in Sundgren (1995).
- Manning’s n value of 0.04 was used for all overland flow calculations.
- The velocity for shallow concentrated flow was provided through a design plot provided in USDA (1985) for non-paved areas.
- A value of 1.75 cfs/acre for the CIA runoff was documented in CH2M Hill (1998) and used for runoff calculations for modeling the 100-year, 24-hour storm event.
- All existing and/or proposed detention basins for developments were not considered because they are designed for a 50-year return interval storm.
- Although the Borrow Area Landfill/West Canyon Pond was designed for the 100-year storm, it is our understanding that the pond is currently being used as a water feature for the Galena Ridge Golf Course. Due to the nature of the area and use of the pond, this feature was not included in any of the modeling processes.
- The lag time was calculated by 0.6 multiplied by the time of concentration as stated in Sundgren (1995).

These assumptions listed above were determined to be key in the hydrologic modeling process and are based upon the best information available at the time.

5.4 Modeling Conditions

The following section specifically discusses the changes and key information relating to each modeling condition. The basic concept and intent of each condition was discussed previously but specific hydrologic modeling information is included below.

5.4.1 “As-designed” Condition (1996)

The first modeling condition included trying to recreate the model as produced in Spectrum (1996). Upon initial assessment of available information, it was thought that sufficient information was given in order to recreate the hydrologic model. After further investigation, it was determined that a complete recreation was not feasible. The Spectrum report only provided input information regarding the 10-year return interval storm.

Recreation of the Spectrum model was still completed and results were compiled, but exact correlation was not achieved. This effort helped in the understanding of the assumptions, inputs, and development of the hydrologic model developed by Spectrum but would ultimately lead to a conclusion that exact replication of the 1996 condition was not possible.

5.4.2 2007 Condition

The next hydrologic modeling condition was referred to as the "2007 condition". This condition is a snap-shot in time of the Bunker Creek watershed as it existed in 2007. This modeling condition used the most recent data available at the time including GIS, survey, and published data for the Kellogg area. As these changes and updates were compiled, Sundgren (1995) was referenced and used as a guide.

An extensive survey of the Bunker Creek channel was conducted by TerraGraphics in 2007 and captured more than 50 cross-sections along Bunker Creek as well as supporting information pertaining to the hillside gulches, CIA, CTP, and the City of Kellogg. This information was used to update the inputs and assumptions used in this modeling effort.

Updates to the soil type, land use, and conditions in the hillside gulches and the City of Kellogg were also developed. These updates came from several sources and can be specifically referenced in the GIS section above. This information was used for determination of curve numbers. Refer to Appendix A for a complete listing of all the information used and associated runoff curve numbers used for the hydrologic model input.

The last update compiled in order to represent this condition was to calculate the estimated travel time for each contributing sub-watershed. This is an important, but highly variable, parameter required for the hydrologic modeling program. Refer to Appendix A for all assumptions and calculations used for travel time.

5.4.3 Design Condition

The next condition is referred to as the "design" condition. This scenario specifically will look at all the surrounding areas to Bunker Creek and determine what the most realistic approximation for future development is. This development of "realistic" was determined through research of the existing conditions, rules and regulations by the City of Kellogg, historic development trends, and current proposed developments. Due to the complexity of the developments and situation of the area, there is no specific year this scenario was projected to but is estimated to be within approximately 25 years.

Two major developments that are proposed are known as the Galena Ridge Golf Course and the Alpine Village. These two developments will take up the majority of the southern gulches land which is most developable.

Some changes and assumptions were used in the re-development of the runoff curve numbers for this design condition. First, the Galena Ridge Golf Course was assumed to have a final land use classification of open area in fair condition due to the vast majority of grass used for a typical golf course. Second, fewer than 10% of the lots in Kellogg are vacant at the current time, so no significant changes in the City of Kellogg were modeled for this condition. Third, the hydrologic condition for all areas that were not developed was increased by one level to account for vegetation and natural growth of the gulch hillsides. The final major update for this condition from 2007 was the area for K4, which was increased by 23.7 acres to account for future storm sewer upgrades in the City of Kellogg. Refer to Appendix A for a complete listing of the information used to develop the runoff curve numbers for this hydrologic modeling condition.

5.4.4 Ultimate Buildout Condition

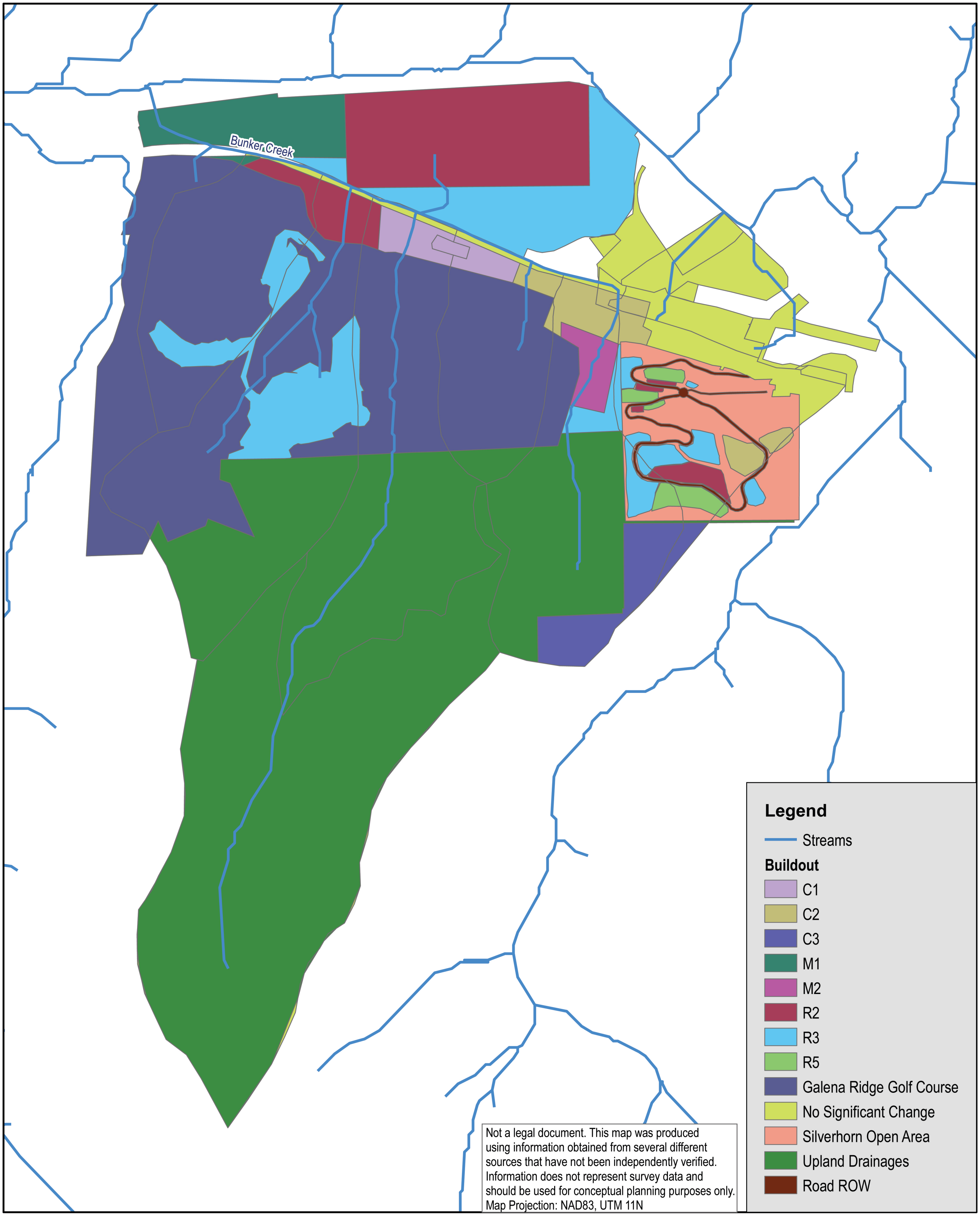
The final modeling condition is referred to as the "ultimate buildout" condition. This scenario is used to show the maximum possible development of Kellogg and surrounding areas. This will help show a relative view of how the developments and regulations will affect the Bunker Creek watershed overall and in the long-term. The majority of the buildout projections were developed based upon the current zoning map of the City of Kellogg. This map outlines the land uses permitted for the entire city and allows for future planning. It is also important to note that the projected development in the areas which are only based upon zoning also assumes the maximum percent impervious area as allowed by City of Kellogg regulations. For a complete listing of the land use types and allowed maximum percent impervious, refer to Table 7.

Table 7 City of Kellogg's Maximum Percent Impervious Restrictions

<table>
<tr><th>Zoning</th><th>Max % Impervious</th></tr>
<tr><td>R-S</td><td rowspan="3">60</td></tr>
<tr><td>R-1</td></tr>
<tr><td>R-2</td></tr>
<tr><td>R-3</td><td>75</td></tr>
<tr><td>C-1</td><td>90</td></tr>
<tr><td>C-B</td><td rowspan="4">100</td></tr>
<tr><td>C-2</td></tr>
<tr><td>M-1</td></tr>
<tr><td>M-2</td></tr>
</table>

A few exceptions include the steep hillsides in the upland gulches which were not shown as developed due to the remote location and distance from Bunker Creek. Developments in these areas were assumed to have minimal impacts to the overall system and were not modeled with changes.

The same changes as stated in the design condition were kept including the increase of the hydrologic condition class by one level as well as the Galena Ridge Golf course being classified as open area in fair condition. Refer to Figure 6 showing locations of possible development around Kellogg.



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FILE	Idaho/Clients/BCreek_A2.MXD
PRINT DATE	June 6, 2008
PROJECT NUMBER	2005:3160-80

Figure 6
Bunker Creek
Ultimate Buildout Condition

1 inch equals 2,000 feet
0 1,000 2,000 Feet
N

5.5 Model Results

The results of the hydrologic model are the flow inputs used in the hydraulic model of the Bunker Creek channel. Summary tables of input values and parameters, as well as output summaries are provided in Appendix A for reference.

The results of this hydrologic model indicate the amount of water that will run off the surrounding gulches and hillsides that feed Bunker Creek. The main comparison for this model was intended to be between Spectrum's model (1996) and the current TerraGraphics model. This direct comparison turned out to be fairly difficult due to the change in several factors such as modeling programs, schematic layout, updates to the area and updated input information. Comparisons will be made in general but specifics could be misleading due to these changes.

Overall, runoff conditions of the surrounding hillside gulches were considered to be relatively poor. The hillsides generally have a low percentage of ground cover, which causes an increase in peak runoff values for large storms. A complete runoff curve number analysis was compiled as stated above and used for all modeling conditions of concern. It is commonly thought that development of natural areas surrounding cities have significant impact on the overall peak runoff in the event of a large storm such as the 100-year storm as modeled. However, due to the poor but improving existing condition seen in the Bunker Creek watersheds, future conditions only have slight impacts on the overall hydrology. The 2007 condition was used as the baseline for comparison to the future modeled conditions. The "design" condition resulted in a slight decrease in peak flow at the downstream end of Bunker Creek. The "buildout" condition resulted in a slight increase of the peak flow from existing at the downstream end of Bunker Creek. These peak flow increases are relatively small and few impacts from development are actually considered to be significant. For complete listing of the output summary for each modeled condition, refer to the Table 8.

Table 8 Peak Discharge for all Modeling Conditions

100-year, 24-hour storm	Spectrum	TerraGraphics		
	1996	2007	Design	Buildout
Peak Flow (cfs)	760	1,473	1,220	1,533

A direct comparison between Spectrum (1996) and the TerraGraphics model is not very informative. As a general statement, it was observed that the flow values for most sub-watershed areas were significantly increased from the peak flows as presented by Spectrum. But it is also important to notice that an increase in curve number was also generated with the TerraGraphics model as a result of changes stated previously. As a result of the significant differences in the peak flow values, the alternative scenarios developed for mitigation use both the Spectrum and TerraGraphics peak flow values in order to bracket the "high" and "low" scenarios.

In order to verify the runoff values that were developed from this model, an additional calculation using the Rational method was completed. This calculation provided a different method and comparison to use along with the developed hydrologic model. Results from the Rational method seemed to follow the trend of the current model. A summary table of this calculation and peak flow values are shown in Appendix A.

SECTION 6.0 HYDRAULIC MODEL

The next phase of this study was to model the hydraulics of the Bunker Creek channel. This model helped determine the condition of the channel for all the hydrologic conditions discussed above. Ultimately the flooding impacts and risks were displayed. Upon analysis of the results for each modeling condition, alternatives were selected and analyzed for flood mitigation if required. The following section specifically discusses all the inputs, assumptions, parameters, and results for each modeling condition.

6.1 Modeling Methodology

In order to completely understand and model the Bunker Creek channel, a separate hydraulic model was employed using output from the HEC-HMS hydrologic model as inputs. This allowed more precise model results as well as much more information on the Bunker Creek channel as it relates to the different hydrologic modeling conditions.

6.1.1 HEC-RAS

The modeling program used for this hydraulic analysis was developed by HEC and is called River Analysis System (HEC-RAS). For a diagrammatic display of the layout for the HEC-RAS model refer to Figure 7. The inputs, assumptions, and parameters used for this model are specifically discussed below.

6.1.2 Input Flows Based on Hydrologic Model Results

The peak runoff flow results produced by the HEC-HMS hydrologic model were used as the primary flow inputs for the HEC-RAS hydraulic model. In addition to the hydrologic model flows, peak flow rates for a 100-year return interval storm for the CIA and CTP were also included. The input values used for the CIA were based upon a design flow per area calculation given in CH2M Hill, 1998. The outfall flow for the CTP was the current, constant flow of approximately 10 cfs as noted by operators of the plant.

6.1.3 Survey and Field Data for Channel Geometry Configuration

The geometry and data used for the channel and surrounding areas for the HEC-RAS model used survey data compiled by TerraGraphics in 2007. An extensive survey of the Bunker Creek channel and surrounding areas included over 50 cross-sections on the main channel as well over 30 cross-sections combined for all the side input channels and areas. All current obstructions, culverts, bridges and miscellaneous features were measured with this survey as well.

However, there were a few areas in which survey data were not collected but field visits and verification was completed. First, there were no surveyed cross sections for Portal Gulch but the culvert data at the junction of Portal Gulch and Bunker Creek was surveyed and used in the model. In addition, no survey data were collected for the stormsewer system throughout Kellogg since the capacity and effectiveness of the system was not being considered. As a result, the hydraulic model starts at the beginning of the open channel portion of Bunker

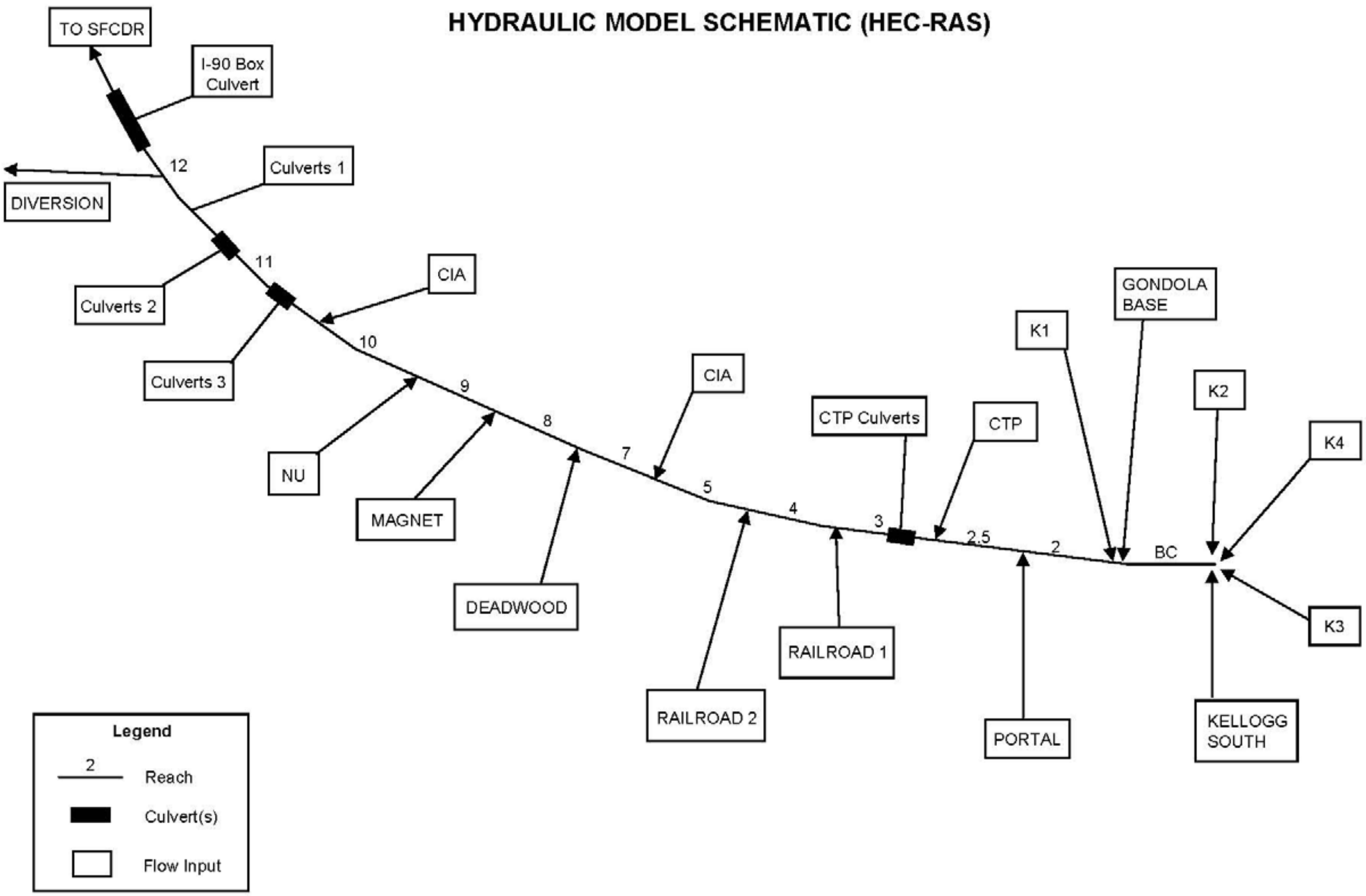


Figure 7 Hydraulic Model Schematic (HEC-RAS)

Creek. No pipe flow modeling prior to this point was considered, however, the flow input value was used.

6.2 Assumptions

All the methodologies and modeling processes used for this study have assumptions and limitations associated with them. This section is not intended to be all inclusive but just to highlight a few main assumptions and limitations found during the modeling process. Most of the limitations, boundary conditions, and assumptions listed below can be further referenced in documentation listed in the reference section at the end of this report.

6.2.1 Model

The HEC-RAS model is a one-dimensional, gradually varied flow model in a steady-state analysis. For detailed description of the assumptions and limitations associated with the HEC-RAS program, refer to USACE (2005).

6.2.2 Input

The following section will discuss the assumptions used for the development of the input data needed to complete the hydraulic model. Most of the data required for HEC-RAS was captured through the survey conducted by TerraGraphics in 2007.

For channel roughness calculations, a Manning's n value is required for each channel cross section. Based upon the standard table for Manning's n (McCuen 2005) a value of 0.027 was selected for the low-flow portion of the channel and a value of 0.035 was used for all remaining areas of the channel for each cross section. This difference was to account for the increased vegetation in the left and right over bank areas that were not present in the low-flow portion of the channel.

Due to the physical characteristics of Railroad Gulch, the flow was split into 2 equal values and input into HEC-RAS in two separate locations. Upon the collection of survey data, it was discovered that the flow is split at the bottom end of Railroad Gulch and then enters into Bunker Creek in two different locations within approximately 100 feet of each other. This feature has minimal effect on the hydraulics for the Bunker Creek channel.

6.3 Modeling Conditions

The modeling conditions for the hydraulic model were kept consistent with the conditions of the hydrologic model. These conditions were developed in order to represent the past, present, and possible future conditions of the Bunker Creek watershed.

The only difference between the various conditions is a change in input peak flow values that were output results from the different hydrologic modeling conditions. The physical channel geometry was kept the same since no known future channel modifications or updates are proposed at this time. This allowed for a consistent and straight-forward analysis to occur for the hydraulics of Bunker Creek. The specifics of the results for each condition are discussed later in this report. Channel modifications were made for the alternative analysis with specific details discussed in section 7.

6.4 Model Results

The following section describes the observed results from the hydraulic model for all conditions modeled on Bunker Creek. The specific output variable of greatest concern is the water surface elevation as it compares to the channel bank elevations as it represents flooding by overtopping the creek banks. Specific velocities and shear stresses were not analyzed. For a complete summary table of output results for each modeling condition, refer to Appendix A.

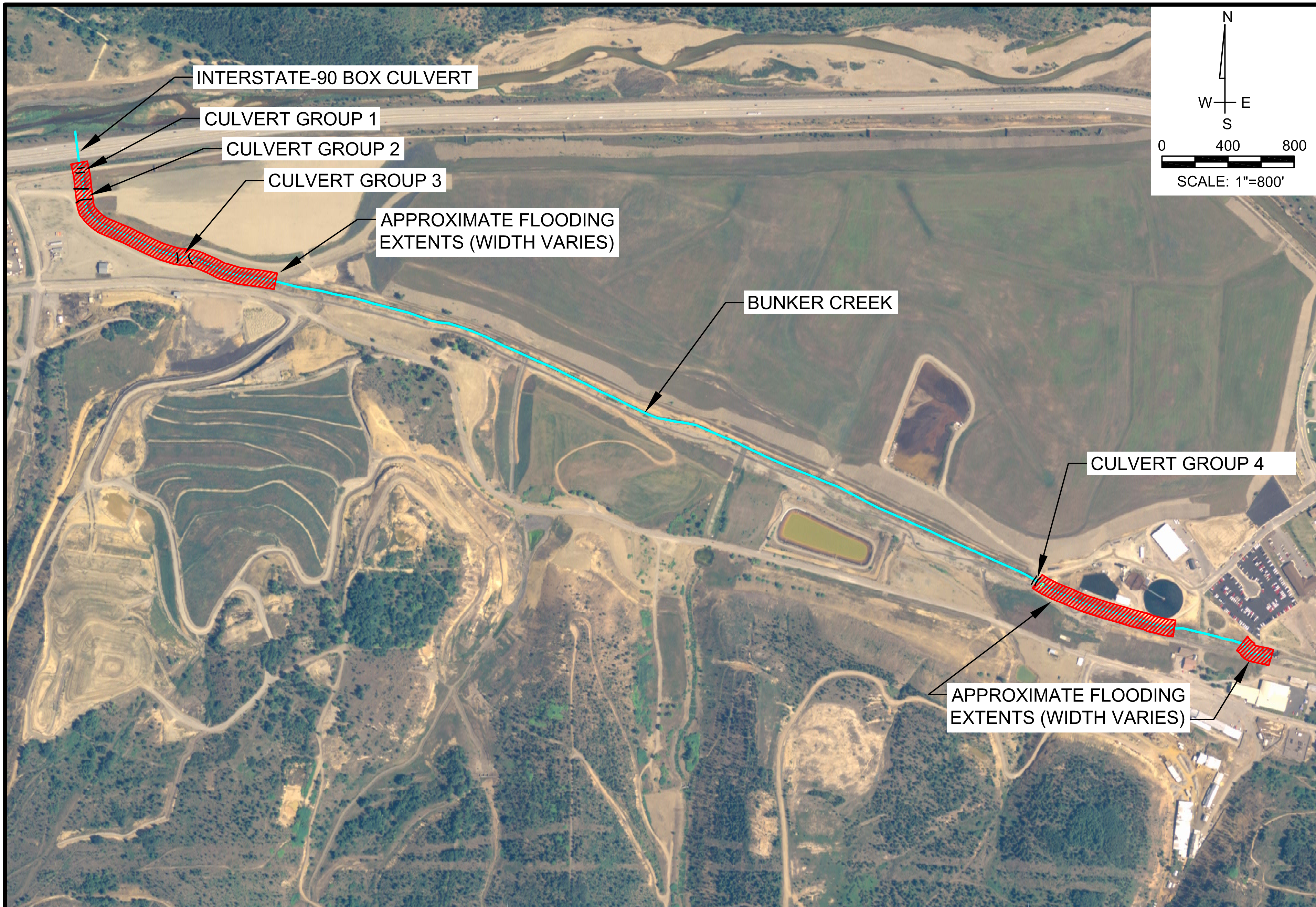
Upon analysis of model output results, it was observed that the downstream end of Bunker Creek is the major limiting factor for capacity of the Bunker Creek channel. There are four sets of existing culverts, referred to as culvert groups, which intensify the flooding problems at the downstream end. Figure 8 shows the approximate area of overbank flooding on Bunker Creek for the existing condition. Similar flooding extents are also observed for both the design and buildout conditions. It is important to note that the flooding problems shown are caused by the series of undersized culverts, including the box culvert under I-90. If Bunker Creek had no culvert restrictions present, the channel itself can convey the entire modeled flow for all conditions developed both from TerraGraphics and Spectrum. The elimination of the undersized culverts is required to pass even the smallest estimated 100-year flood.

Passage of overflow from Bunker Creek has been assumed to be dependent upon the diversion channel to Government Gulch. Spectrum (1996) reported full flow capacity of the I-90 culvert at Government Gulch at 1,500 cfs. Modeling of flow through the culvert in HEC-RAS and FishXing confirmed this capacity. However, a headwater depth of 38 feet was required to achieve this flow through the culvert. Assuming a freeway elevation of 2,240’ at the Government Gulch box culvert, the available headwater depth is approximately 6 feet before overtopping the freeway. With a tailwater elevation of 2,238.2, as provided by the FEMA FIS for Kellogg, and the freeway elevation of 2,240’, capacity of the Government Gulch box culvert is reduced to approximately 400 cfs. Spectrum (1996) projected a flow of 386 cfs down Government Gulch in a 25-year return interval flood. For this reason, no flow was diverted to Government Gulch in our modeling of a 100-year return interval flood for Bunker Creek. This elimination of overflow through the diversion channel increased flooding conditions throughout Bunker Creek.

Spectrum (1996) gave the full flow capacity of the Bunker Creek I-90 Culvert as 260 cfs. This was confirmed in our analysis as well. TerraGraphics’ hydrologic model indicated a 100-year interval flood flow of 1,473 cfs for the 2007 condition, and 1,550 cfs for a build-out condition. These flows are significantly higher than the box culvert capacity and result in freeway overtopping and overbank flow in Bunker Creek. Figure 9 displays a profile plot from the HEC-RAS model for the modeled conditions. The I-90 box culvert is shown in reach “Bunker Main 12” and the three culvert groups are shown in reach “Bunker Main 11”. Note the extensive backwater and freeway overtopping present at the downstream end of Bunker Creek. It is important to note this modeling condition did not include extensive modeling of the possible effects for flood conveyance westward of Bunker Creek, flooding impacts from Government Creek or topography and buildings west of Bunker Creek. This condition shows the analysis based upon no significant conveyance capacity from Bunker Creek to the west towards Government Creek and Smelterville.

In order to quantify the current condition of Bunker Creek, the 10-year 24-hour storm event was modeled as provided by Spectrum, 1996. Results from this model display slight flooding conditions caused by culvert groups 2 and 3. Therefore, Bunker Creek can pass less than the 10-year, 24-hour storm event in the existing condition. Next, the existing condition with the removal of all the culvert groups upstream of the I-90 box culvert was modeled. The capacity of Government Gulch culvert was determined to be 400 cfs, based upon a freeway elevation of 2,240 ft. Flow in Government Gulch was assumed to be 262 cfs, as modeled by Spectrum, therefore flow diverted to Government Gulch from Bunker Creek was set at 138 cfs. The output demonstrated that the Bunker Creek I-90 box culvert will pass the flow from a 10-year 24-hour storm assuming flow values from Spectrum, 1996. Next, the results of a 25-year interval storm were modeled, using a flow of 488 cfs in Bunker Creek, as reported by Spectrum, 1996. Flow diverted to Government Gulch was set at 14 cfs. This was based on a flow of 386 cfs in Government Gulch provided by Spectrum, 1996 and the assumption of a 400 cfs capacity for the Government Gulch I-90 box culvert. The Bunker Creek I-90 box culvert was determined to be undersized. It was not able to pass sufficient flow from a 25-year, 24-hour storm event in order to prevent water from overtopping the freeway and the banks of Bunker Creek. Therefore, it was determined the Bunker Creek box culvert under I-90 has a capacity between the 10 and 25-year event as shown without overtopping the interstate or the channel banks. Figure 10 displays the HEC-RAS profile plot for the 10-year, 24-hour storm event.

The alternative analysis considered both the TerraGraphics and Spectrum flow scenarios to help show a range of possibilities for Bunker Creek. Section 7 will discuss details of this alternative analysis in greater detail.



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PROJECT MANAGER: A. HEITMANN	DATE: 06/10/08	

FIGURE 8
FLOODING REGIONS FOR EXISTING CONDITION

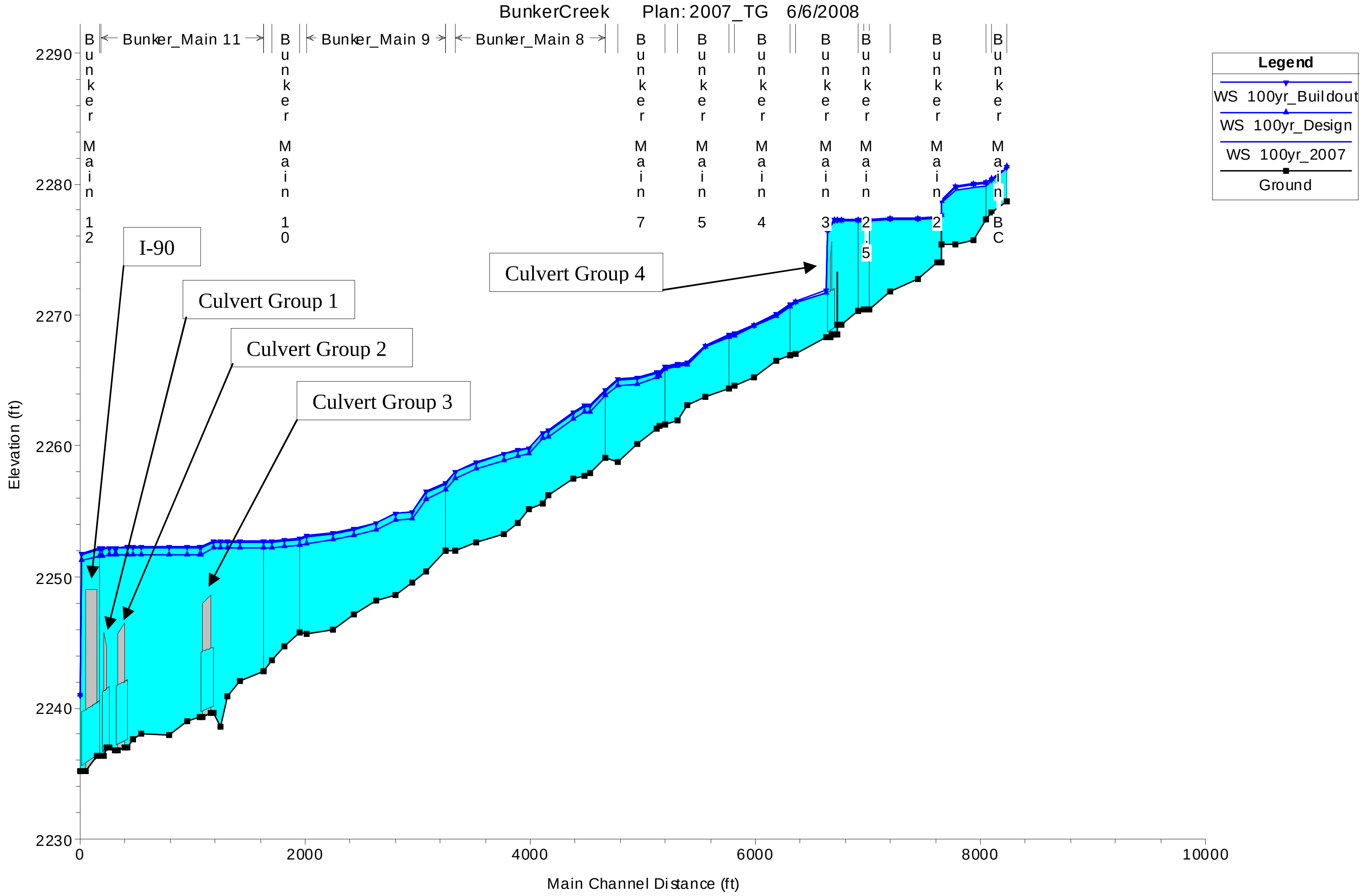


Figure 9 HEC-RAS Profile Plot for Existing Conditions

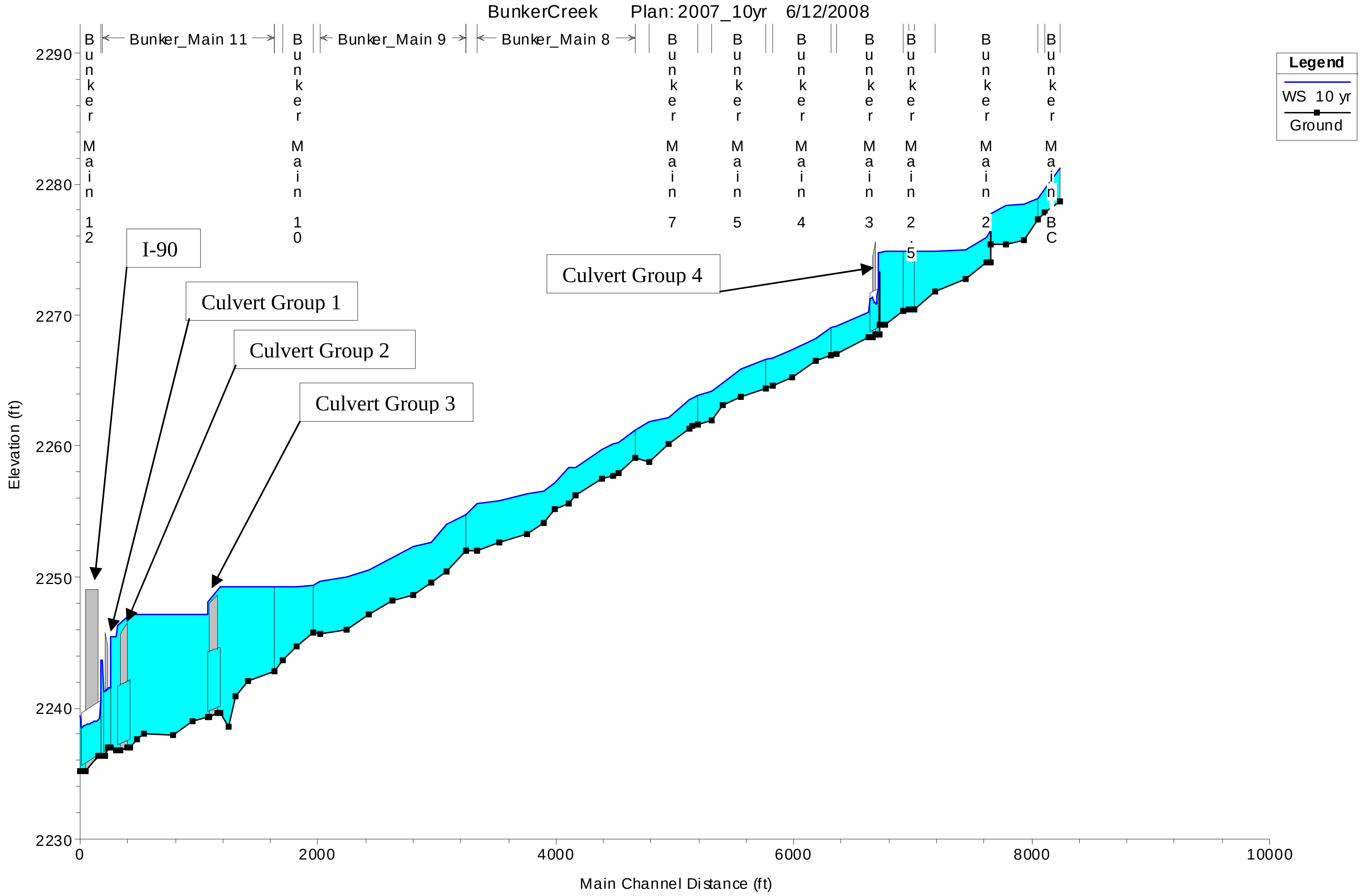


Figure 10 HEC-RAS Profile Plot for 10-Year Storm Event

SECTION 7.0 ALTERNATIVE GENERATION & ANALYSIS

The final section of the Bunker Creek study was to evaluate the conditions of the entire area of concern and provide mitigation alternatives for flooding, if any. Model results indicated significant flooding impacts to several different areas of the Bunker Creek channel especially at the downstream end. The following discussion will talk about the criteria, type and specifics of the alternatives modeled for mitigation of the flooding effects.

7.1 Criteria for Alternative Selection

Prior to development of alternatives or options for flood mitigation, a set of criteria were developed with which to evaluate the alternatives. These criteria helped to guide the development of these alternatives in order to provide solutions that meet most if not all the criteria provided. A brief discussion about each criterion is discussed below and a synopsis is shown in Table 9.

7.1.1 Feasibility

The feasibility of the alternative was evaluated. The main driver for this criterion was construction feasibility. The alternatives were based upon the construction feasibility as they are related to each other. Each alternative was also evaluated on whether the type of construction was considered “typical” or common practice.

7.1.2 Cost Effectiveness

The next criterion used for evaluation of the alternatives was the cost effectiveness. The cost for design and construction of each alternative could have a significant impact in the determination of the selected alternative. The cost analysis for each alternative does not provide numbers; this analysis is based upon a relative scale between all the alternatives evaluated. Further cost analysis and evaluation is highly recommended prior to further exploration into design work for the flooding mitigation.

7.1.3 Prevents Overtopping of Freeway

Bunker Creek flows under I-90 and into the SFCDR through an existing box culvert. To ensure that the design has minimal impact on I-90, a specific evaluation of whether the interstate is overtopped by the flooding was completed. This criterion was fairly straight forward in the sense that there was either overtopping or not. It was considered to be a failed alternative if the freeway overtopped due to the extensive cost and damage that could be generated by this action.

7.1.4 Flow Remains within Channel Entire Length

The next criterion is that flows remain within the creek channel preventing overtopping of the creek banks. This criterion was considered important due to the highly sensitive areas adjacent to Bunker Creek. The surrounding areas consist of the CIA, UPRR Bike Trail and remediated properties. This criterion was specifically a concern of Idaho Department of

Environmental Quality and stakeholders for this project and was held to a high standard as the development of these scenarios was completed.

7.1.5 Provides Floodwater Storage Capacity

Due to the existing conditions of the Bunker Creek channel, I-90, and proximity to Government Gulch, providing some floodwater storage capacity was considered to be very applicable and valuable for this analysis. This criterion did not have to be met but increased the value of the alternative. Significant calculations and modeling of this storage were not completed but a general estimate was used for the alternatives.

7.1.6 Does Not Impede on Adjacent Property

The final criterion used for evaluation was whether the alternatives had the possibility of impeding on any adjacent property either by flooding or construction activities. As discussed previously, there are several areas where construction, channel flow, or flooding is not acceptable due to previous remediation and/or land ownership.

7.2 Alternative Descriptions

Several scenarios were investigated to explore ways to mitigate a 100-year, 24-hour duration storm event. All scenarios were based upon removal of the four groups of existing culverts upstream of the I-90 box culvert along Bunker Creek. The upstream culvert capacities were found to be undersized, causing backwater and overtopping the banks of Bunker Creek. The three following scenarios were modeled to establish changes required to pass flow without overtopping the freeway or banks for a 100-year, 24-hour duration storm event.

All the alternatives listed below are proposed physical changes to Bunker Creek and the surrounding area. It is important to note that administrative alternatives will help with future efforts to help mitigate future problems. However, these administrative alternatives will not help the current flooding problem. These alternatives were not the focus of this report due to the existing flooding condition.

7.2.1 Scenario 1

In scenario 1, all the culvert groups upstream of the I-90 box culvert were removed. The 100-year, 24-hour duration storm from both Spectrum and TerraGraphics studies were used for comparison. Results indicated there were still significant overtopping of the interstate as well as overbank flow of the channel. This scenario provided a slight increase in overall channel capacity but this capacity is still significantly less than the 100-year flood event as presented by either study. This scenario was not considered to be sufficient to provide mitigation to the existing flooding problems. A summary of how this alternative meets the selected criteria is shown in Table 9.

7.2.2 Scenario 2

In scenario 2, the results of a 100-year 24-hour storm event were modeled using Spectrum's reported flow values of 600 cfs in Government Gulch and 760 cfs in Bunker Creek. The capacity of Government Gulch I-90 box culvert was set at 400 cfs; therefore no flow was diverted from Bunker Creek to Government Gulch. Initial channel alterations consisted only of removal of the culverts upstream of the I-90 box culvert. Flow overtopped the freeway and downstream banks. For further mitigation, enlargement of the channel bed and the addition of culverts under I-90 were explored. First, expansion of reach 12 of Bunker Creek to a bottom width of 250 ft was modeled. This alternative alone was not sufficient to prevent flow overtopping the downstream banks. The addition of a corrugated metal pipe culvert under I-90, in addition to the existing box culvert, was investigated. The mitigation alternative which prevented flow from overtopping the freeway and banks of Bunker Creek utilized expansion of approximately 200 ft of length of the channel to a bottom width of 250 ft, and the addition of two seven ft diameter culverts adjacent to the existing box culvert under I-90. Figure 11 displays the profile plot from HEC-RAS for this alternative configuration. It is noted that the freeway overtopping is solved as well as overbank flow along the entire length of Bunker Creek.

7.2.3 Scenario 3

In scenario 3, flow values based upon TerraGraphics hydrologic model were used to model a 100-year, 24-hour storm. The highest peak flow in Bunker Creek of all conditions was used for a conservative approach. The peak flow value was 1,533 cfs. No flow was diverted to Government Gulch. All culverts upstream of the I-90 box culvert were removed in the model. No feasible and reasonable configuration of channel expansion and additional culverts was found sufficient to pass the flow. As a solution, the Bunker Creek I-90 box culvert was removed and replaced with a clear-span bridge. The bridge spanned approximately 80 feet, provided 20 ft of channel bottom width, and creek banks with 3:1 side slopes. Refer to Figure 12 and Figure 13 for a HEC-RAS profile plot and conceptual drawing of the channel and bridge configuration, respectively. This alternative readily passed the 100-year, 24-hour peak flow as described.

7.3 Alternative Analysis and Comparison

Based upon the current conditions as shown by the hydrologic and hydraulic models for the Bunker Creek system, mitigation for flooding is recommended. Under existing conditions, the best case modeled 100-year storm event will still result in extensive flooding. Due to the complexity and conditions of the Bunker Creek channel, a single solution which met all criteria was not found. Table 9 displays an alternative analysis matrix which compares all described alternatives against all selected criteria. This table indicates Scenario 3 to rate among the top for most of the criteria except for cost. An estimate of cost for these scenarios was on a comparative basis and approximate values were not given due to the unknown factors which will have to be explored upon further development of the mitigation alternatives. All alternatives met most of the criteria to some degree but a comparison between them was still evaluated.

Table 9 Alternative Analysis Criteria Matrix

Criteria	**Scenario 1 –** No Culvert Groups	**Scenario 2 –** Add I-90 Culverts, Widen Channel	**Scenario 3 –** No Culverts, Add Bridge
Cost effective/ Economical	Good	Poor	Poor
Feasible	Good	Fair	Good
Prevents overtopping of freeway	Failed	Good	Excellent
Keeps flow inside channel	Failed	Good	Excellent
Provides floodwater storage capacity	Failed	Fair	Good
Does not impede on adjacent property	Excellent	Poor	Excellent

7.4 Recommendations and Future Work

This study examined several different aspects of the Bunker Creek watershed and drainage system and helped qualify the changes that have occurred to the surrounding area since Spectrum's study (1996). The alternatives listed for flooding mitigation were based upon conceptual planning and ideas. More modeling, research, and design should be completed to fully evaluate the best alternative for flood mitigation.

Since the collection of data for this study occurred, several new surface water gauges have been installed and measurements have been acquired. Collection of these data and information over time will greatly increase the applicability of this assessment for the Bunker Creek system. It is recommended that these data be used to calibrate the Bunker Creek study models and provide more accurate peak flows to the Bunker Creek watershed. The integration of this model into an area-wide modeling effort is also recommended.

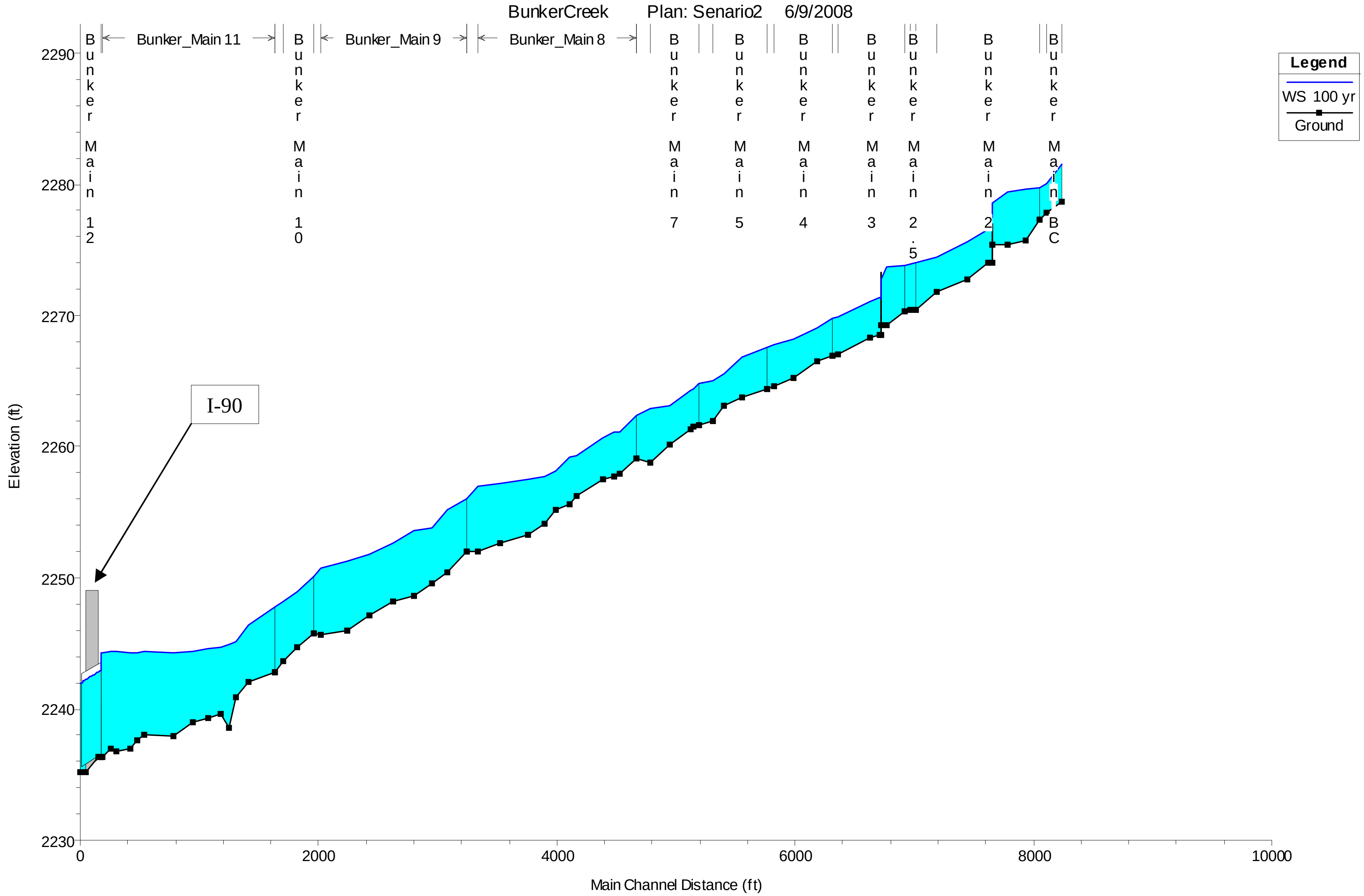


Figure 11 HEC-RAS Profile Plot for Scenario 2

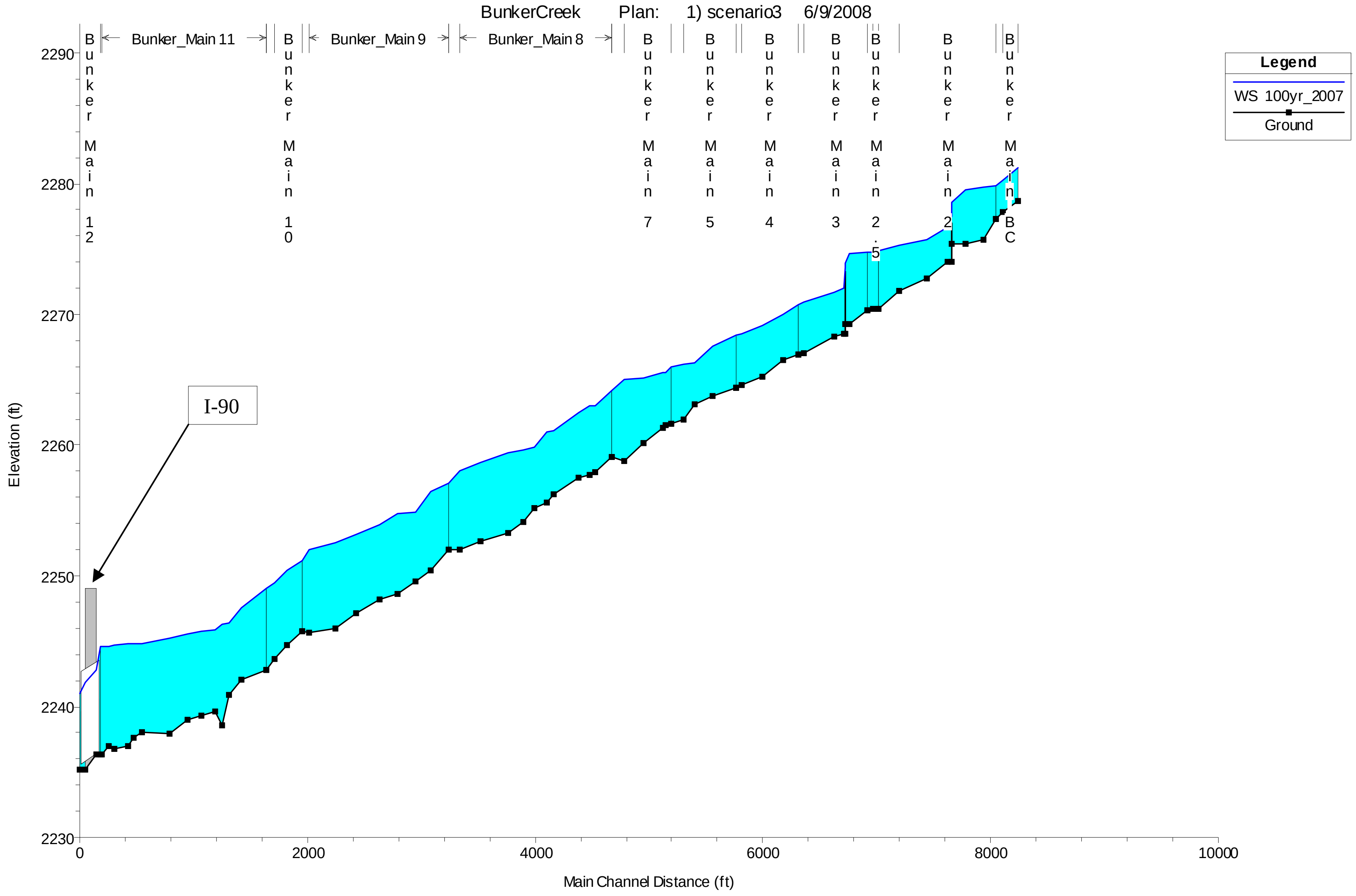
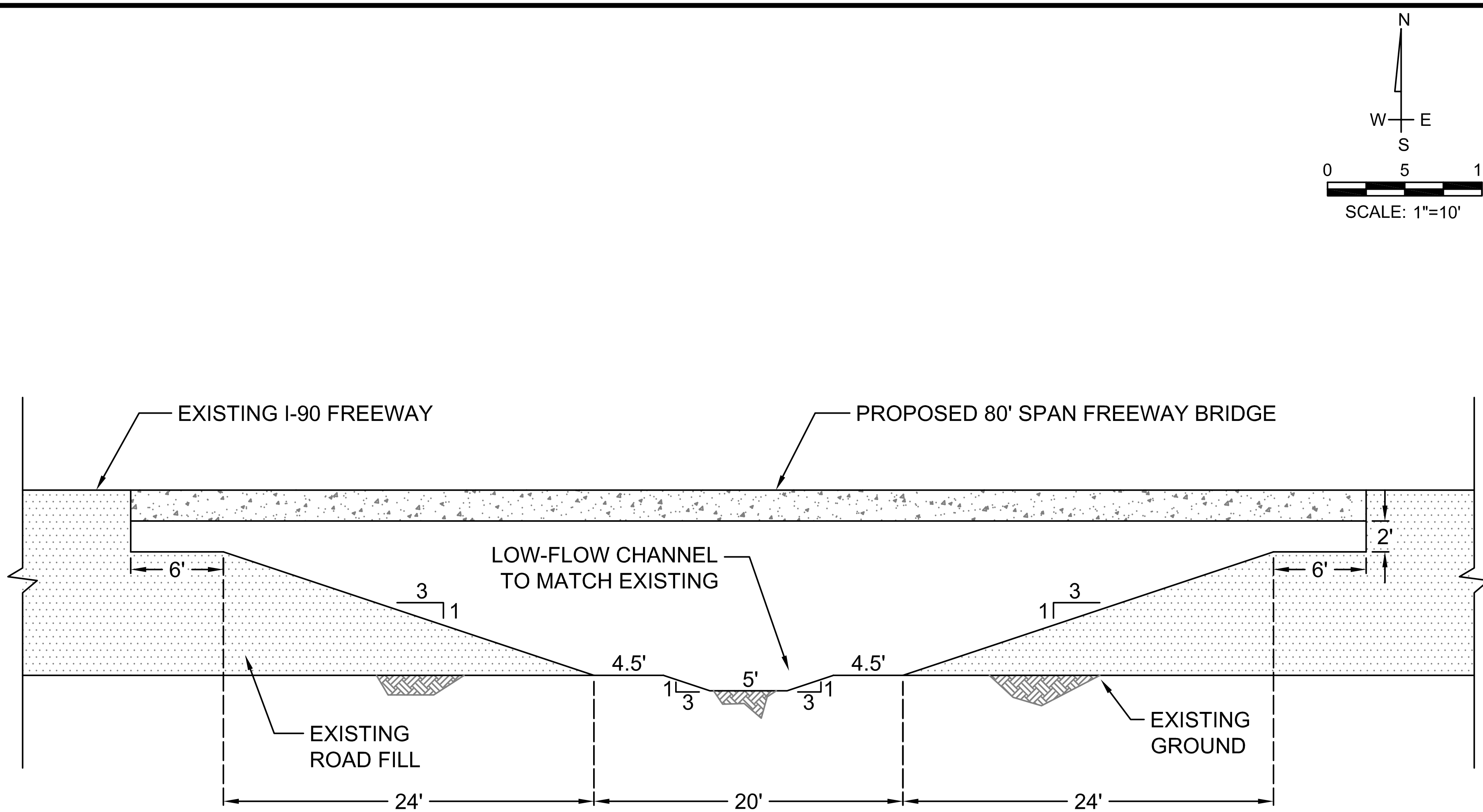


Figure 12 HEC-RAS Profile Plot for Scenario 3



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DRAWN BY: C. HALEY	PROJECT NO: 2005-3160	PROJECT NAME: BUNKER CREEK STUDY KELLOGG, IDAHO	FIGURE 13 PROPOSED FREEWAY BRIDGE SCHEMATIC
PROJECT MANAGER: A. HEITMANN	DATE: 06/06/08		

SECTION 8.0 REFERENCES

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Appendix A

Supporting Calculations

Curve Number Generation Tables for 2007 Condition

Soil Name	*% Slope*	*Map #*	*Soil Group*	*Cover Type*	*% Cover*	*Land Use*	*Hydro Cond.*	*Area (ac)*	*CN*	*CN * Area*
Deadwood Lower										
Hobo silt loam	33.49	35	D	Shrub/Scrub	0.0	Range	Poor	15.19	89	1352
Hobo silt loam	36.55	35	D	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	4.49	89	400
Hobo-Helmer silt loam, severely eroded	16.77	37	D	Shrub/Scrub	0.0	Range	Poor	12.97	89	1155
Tigley family, gulled	62.06	87	B	Shrub/Scrub	0.0	Range	Poor	9.08	79	717
Honeyjones-Ahrs association	41.91	43	B	Grassland/Herbaceous	0.0	Meadow	Poor	0.61	58	36
Udarents-Aquic	13.50	90	C	Barren Land (Rock/Sand/Clay)	0.2	Noncultivated Land	Poor	39.22	86	3373
Slickens	2.49	85	C	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	7.28	86	626
Hugus gravelly loam, severely eroded	47.18	45	B	Shrub/Scrub	1.8	Range	Poor	187.96	79	14849
Total								**276.80**		**22507**
Average	***31.74***								***81.3***	
Deadwood Upper										
Tigley family, gulled	65.23	87	B	Shrub/Scrub	2.3	Range	Poor	41.27	79	3260
Honeyjones-Ahrs association	56.95	43	B	Evergreen Forest	0.0	Woods	Poor	182.34	66	12034
Honeyjones-Ahrs association	27.80	41	B	Evergreen Forest	46.9	Woods	Fair	24.25	60	1455
Honeyjones-Ahrs association	48.18	42	B	Evergreen Forest	79.0	Woods	Good	177.85	55	9782
Latour gravelly silt loam	25.93	60	B	Evergreen Forest	79.4	Woods	Good	11.37	55	626
Latour gravelly silt loam	23.80	61	B	Shrub/Scrub	66.5	Range	Fair	0.09	69	6
Hugus gravelly loam, severely eroded	48.67	45	B	Shrub/Scrub	0.0	Range	Poor	65.65	79	5187
Total								**502.83**		**32350**
Average	***42.37***								***64.3***	
Gondola Base										
Udarents-Aquic	2.36	90	C	Developed, Medium Intensity	15.2	Industrial	Poor	29.78	91	2710
Udarents-Aquic	1.89	90	C	Developed, Medium Intensity	0.0	Paved Areas	N/A	12.05	98	1181
Total								**41.84**		**3891**
Average	***2.12***								***93.0***	
K1										
Udarents-Aquic	1.92	90	C	Developed, Low Intensity	0.0	Residential	N/A	14.19	90	1277
Udarents-Aquic	3.03	90	C	Developed, Low Intensity	0.0	Paved Areas	N/A	2.02	98	198
Total								**16.21**		**1475**
Average	***2.47***								***91.0***	
K2										
Udarents-Aquic	1.80	90	C	Developed, Medium Intensity	0.0	Industrial	N/A	1.85	91	168
Total								**1.85**		**168**
Average	***1.80***								***91.0***	

Soil Name	% Slope	Map #	Soil Group	Cover Type	% Cover	Land Use	Hydro Cond.	Area (ac)	CN	CN * Area
K3										
Hobo-Helmer silt loam, severely eroded	1.37	37	D	Developed, Medium Intensity	0.0	Industrial	N/A	10.93	93	1016
Udarents-Aquic	1.87	90	C	Developed, Medium Intensity	0.0	Industrial	N/A	12.40	91	1129
Total								**23.33**		**2145**
Average	***1.62***								***91.9***	
K4										
Hobo-Helmer silt loam, severely eroded	6.59	37	D	Developed, Medium Intensity	0.0	Industrial	N/A	1.18	93	109
Udarents-Aquic	1.72	90	C	Developed, Medium Intensity	0.0	Industrial	N/A	12.15	91	1106
Hobo-Helmer silt loam, severely eroded	12.17	37	D	Developed, High Intensity	0.0	Commercial	N/A	2.64	95	251
Total								**15.97**		**1466**
Average	***6.83***								***91.8***	
Kellogg South										
Hobo-Helmer silt loam, severely eroded	8.82	37	D	Developed, Medium Intensity	0.0	Industrial	N/A	4.24	93	395
Udarents-Aquic	8.62	90	C	Developed, High Intensity	0.0	Commercial	N/A	0.46	94	43
Hobo-Helmer silt loam, severely eroded	6.84	37	D	Developed, Medium Intensity	0.0	Industrial	N/A	13.95	93	1297
Hobo silt loam	27.52	35	D	Shrub/Scrub	0.0	Range	Poor	88.29	89	7858
Hobo-Helmer silt loam, severely eroded	23.91	37	D	Shrub/Scrub	22.9	Range	Poor	9.45	89	841
Hugus gravelly loam, severely eroded	35.48	45	B	Shrub/Scrub	26.2	Range	Poor	16.68	79	1317
Lotuspoint, eroded	21.45	64	C	Shrub/Scrub	16.1	Range	Poor	3.06	86	263
Tigley family, gulled	44.57	87	B	Evergreen Forest	22.1	Woods	Poor	0.91	66	60
Udarents-Aquic	6.50	90	C	Developed, Medium Intensity	77.3	Industrial	N/A	5.88	91	535
Hugus gravelly loam, severely eroded	30.96	45	B	Shrub/Scrub	0.0	Range	Poor	13.54	79	1070
Total								**156.46**		**13679**
Average	***21.47***								***87.4***	
Magnet Gulch										
Hobo silt loam	23.66	35	D	Shrub/Scrub	0.0	Range	Poor	126.48	89	11257
Hobo-Helmer silt loam, severely eroded	12.93	37	D	Shrub/Scrub	0.0	Range	Poor	3.65	89	325
Hobo-Helmer silt loam, severely eroded	14.57	37	D	Shrub/Scrub	0.0	Range	Poor	44.45	89	3956
Hugus gravelly loam, severely eroded	32.85	45	B	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	13.57	79	1072
Tigley family, gulled	40.33	87	B	Shrub/Scrub	0.0	Range	Poor	3.96	79	313
Honeyjones-Ahrs association	46.78	43	B	Evergreen Forest	57.8	Woods	Fair	3.27	60	196
Udarents-Aquic	13.06	90	C	Developed, Low Intensity	0.0	Residential	N/A	6.37	90	574
Slickens	5.50	85	C	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	12.62	86	1085
Hugus gravelly loam, severely eroded	43.82	45	B	Barren Land (Rock/Sand/Clay)	0.1	Noncultivated Land	Poor	101.51	79	8019
Total								**315.88**		**26796**
Average	***25.95***								***84.8***	

Soil Name	*% Slope*	*Map #*	*Soil Group*	*Cover Type*	*% Cover*	*Land Use*	*Hydro Cond.*	*Area (ac)*	*CN*	*CN * Area*
				NU Gulch						
Hobo silt loam	24.85	35	D	Shrub/Scrub	0.0	Range	Poor	35.01	89	3115
Hobo-Helmer silt loam, severely eroded	10.79	37	D	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	64.89	89	5775
Hugus gravelly loam, severely eroded	12.89	45	B	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	1.27	79	100
Slickens	13.98	85	C	Shrub/Scrub	0.0	Range	Poor	60.07	86	5166
Hugus gravelly loam, severely eroded	24.87	45	B	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	1.12	79	88
Total								**162.35**		**14245**
Average	***17.48***								***87.7***	
				Portal Gulch						
Hobo silt loam	38.46	35	D	Shrub/Scrub	0.0	Range	Poor	7.20	89	641
Hobo-Helmer silt loam, severely eroded	16.59	37	D	Shrub/Scrub	7.4	Range	Poor	5.80	89	516
Hobo silt loam	24.24	35	D	Evergreen Forest	46.2	Woods	Fair	37.84	79	2989
Hobo-Helmer silt loam, severely eroded	31.67	37	D	Shrub/Scrub	0.0	Range	Poor	1.01	89	90
Tigley family, gulled	47.70	87	B	Shrub/Scrub	23.6	Range	Poor	12.25	79	967
Udarents-Aquic	11.32	90	C	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	17.27	86	1485
Hugus gravelly loam, severely eroded	48.60	45	B	Shrub/Scrub	19.6	Range	Poor	157.54	79	12446
Total								**238.91**		**19135**
Average	***31.22***								***80.1***	
				Railroad Gulch						
Hobo silt loam	30.00	35	D	Shrub/Scrub	2.1	Range	Poor	32.89	89	2928
Hobo-Helmer silt loam, severely eroded	18.37	37	D	Shrub/Scrub	0.2	Range	Poor	35.59	89	3168
Hobo-Helmer silt loam, severely eroded	11.57	37	D	Shrub/Scrub	3.4	Range	Poor	5.41	89	482
Udarents-Aquic	8.40	90	C	Barren Land (Rock/Sand/Clay)	0.3	Noncultivated Land	Poor	21.73	86	1869
Slickens	0.12	85	C	Barren Land (Rock/Sand/Clay)	0.0	Noncultivated Land	Poor	3.66	86	315
Hugus gravelly loam, severely eroded	44.68	45	B	Shrub/Scrub	20.6	Range	Poor	25.60	79	2023
Total								**124.90**		**10784**
Average	***18.86***								***86.3***	

Curve Number Generation Tables for Design Condition

Soil Name	*% Slope*	*Map #*	*Soil Group*	*Development Classification*	*Existing Cond. Cover Type*	*% Cover*	*Land Use*	*Hydro Cond.*	*Area (ac)*	*CN*	*CN * Area*
					Deadwood Lower						
Hobo silt loam	36.45	35	D	Galena Ridge Golf Course	Shrub/Scrub	N/A	Open Space - Fair Condition	N/A	28.56	84	2,399.04
Hugus gravelly loam, severly eroded	39.56	45	B	Galena Ridge Golf Course	Shrub/Scrub	N/A	Open Space - Fair Condition	N/A	34.79	69	2,400.70
Udarents-Aquic	15.73	90	C	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	N/A	Open Space - Fair Condition	N/A	25.73	79	2,032.72
Hobo silt loam	28.51	35	D	Single Family	Shrub/Scrub	N/A	Single Family Residential	N/A	4.15	91	376.82
Hobo silt loam	17.52	35	D	N/A	Shrub/Scrub	0.00	Range	Fair	0.27	84	23.07
Hugus gravelly loam, severly eroded	48.95	45	B	N/A	Shrub/Scrub	0.57	Range	Fair	162.53	69	11,214.57
Slickens	0.01	85	C	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	3.64	79	287.56
Slickens	6.15	85	C	N/A	Shrub/Scrub	0.00	Range	Fair	3.21	79	253.59
Slickens	3.69	85	C	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	2.11	79	167.00
Udarents-Aquic	8.40	90	C	N/A	Developed, Low Intensity	0.54	Residential	N/A	11.79	90	1,061.46
Total									**276.80**		**20217**
Average	***20.50***									***73.0***	
					Deadwood Upper						
Honeyjones-Ahrs association	48.16	42	B	N/A	Evergreen Forest	79.52	Woods	Good	450.17	55	24,759.35
Latour gravelly silt loam	26.95	60	B	N/A	Evergreen Forest	67.02	Woods	Good	11.30	55	621.59
Tigley family, gulled	65.40	87	B	N/A	Shrub/Scrub	2.26	Range	Fair	41.18	69	2,841.55
Total									**502.65**		**28222**
Average	***46.84***									***56.1***	
					Gondola Base						
Udarents-Aquic	2.41	90	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	29.78	91	2,709.98
Udarents-Aquic	1.93	90	C	N/A	Paved Area	0	Paved Area	N/A	12.05	98	1,181.36
Total									**41.83**		**3891**
Average	***2.17***									***93.0***	
					K1						
Udarents-Aquic	2.11	90	C	N/A	Developed, Low Intensity	0.00	Residential	N/A	14.18	90	1,276.46
Udarents-Aquic	4.21	90	C	N/A	Paved Area	0	Paved Area	N/A	2.02	98	198.11
Total									**16.20**		**1475**
Average	***3.16***									***91.0***	
					K2						
Udarents-Aquic	1.86	90	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	1.85	91	168.08
Total									**1.85**		**168**
Average	***1.86***									***91.0***	
					K3						
Hobo-Helmer silt loam, severely eroded	1.36	37	D	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	10.92	93	1,015.54
Udarents-Aquic	1.63	90	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	9.50	91	864.44
Udarents-Aquic	2.79	90	C	N/A	Developed, High Intensity	0.00	Commercial	N/A	2.90	94	272.90
Total									**23.32**		**2153**
Average	***1.93***									***92.3***	
					K4						
Hobo-Helmer silt loam, severely eroded	12.18	37	D	N/A	Developed, High Intensity	0.00	Commercial	N/A	2.64	95	250.85
Hobo-Helmer silt loam, severely eroded	8.20	37	D	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	1.18	93	109.48
Udarents-Aquic	1.97	90	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	35.85	91	3,262.35
Total									**39.67**		**3623**
Average	***7.45***									**91.3**	

Soil Name	% Slope	Map #	Soil Group	Development Classification	Existing Cond. Cover Type	% Cover	Land Use	Hydro Cond.	Area (ac)	CN	CN * Area
Kellogg South											
Hobo silt loam	16.40	35	D	Duplex-Triplex	Shrub/Scrub	32.43	Multi-Family Residential	N/A	8.85	94	827.48
Hobo silt loam	20.47	35	D	Hotel Commercial	Shrub/Scrub	21.96	Commercial - General	N/A	6.12	98	599.28
Hugus gravelly loam, severly eroded	26.09	45	B	Hotel Commercial	Evergreen Forest	0.00	Commercial - General	N/A	0.47	98	45.76
Lotuspoint, eroded	19.17	64	C	Hotel Commercial	Shrub/Scrub	28.00	Commercial - General	N/A	1.69	98	165.32
Hobo silt loam	23.46	35	D	Multi-Family	Shrub/Scrub	22.34	Multi-Family Residential	N/A	12.51	94	1,169.69
Hugus gravelly loam, severly eroded	30.39	45	B	Multi-Family	Shrub/Scrub	0.00	Multi-Family Residential	N/A	0.50	89	44.80
Hobo silt loam	30.46	35	D	Road ROW	Shrub/Scrub	12.93	Impervious Area	N/A	8.49	98	832.02
Hugus gravelly loam, severly eroded	54.09	45	B	Road ROW	Shrub/Scrub	0.00	Impervious Area	N/A	0.21	98	20.74
Lotuspoint, eroded	24.53	64	C	Road ROW	Shrub/Scrub	0.00	Impervious Area	N/A	0.37	98	36.26
Hobo silt loam	19.62	35	D	Single Family	Evergreen Forest	44.80	Single Family Residential	N/A	10.32	91	937.06
Hobo silt loam	16.30	35	D	N/A	Developed, Low Intensity	0.00	Residential	N/A	2.30	92	211.47
Hobo silt loam	27.45	35	D	N/A	Shrub/Scrub	7.33	Range	Fair	2.26	84	189.84
Hobo silt loam	25.69	35	D	N/A	Shrub/Scrub	36.00	Range	Fair	1.60	84	134.40
Hobo silt loam	33.06	35	D	N/A	Shrub/Scrub	20.53	Range	Fair	45.88	84	3,853.92
Hobo-Helmer silt loam, severely eroded	6.75	37	D	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	17.73	93	1,648.89
Hugus gravelly loam, severly eroded	30.74	45	B	N/A	Developed, Low Intensity	3.82	Residential	N/A	10.14	85	861.90
Hugus gravelly loam, severly eroded	39.79	45	B	N/A	Shrub/Scrub	24.64	Range	Fair	13.43	69	926.67
Hugus gravelly loam, severly eroded	39.86	45	B	N/A	Shrub/Scrub	0.00	Range	Fair	0.35	69	24.04
Hugus gravelly loam, severly eroded	33.76	45	B	N/A	Evergreen Forest	52.45	Woods	Good	5.97	55	328.35
Lotuspoint, eroded	31.23	64	C	N/A	Shrub/Scrub	0.00	Range	Fair	0.77	79	61.00
Lotuspoint, eroded	26.42	64	C	N/A	Shrub/Scrub	21.00	Range	Fair	0.40	79	31.74
Udarents-Aquic	11.06	90	C	N/A	Developed, High Intensity	0.00	Commercial	N/A	0.32	94	29.74
Udarents-Aquic	9.02	90	C	N/A	Developed, Low Intensity	0.00	Residential	N/A	2.71	90	243.95
Udarents-Aquic	4.59	90	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	3.17	91	288.40
Total									**156.55**		**13513**
Average	***25.02***									***86.3***	
Magnet Gulch											
Hobo silt loam	24.47	35	D	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	0.00	Open Space - Fair Condition	N/A	92.17	84	7,742.28
Hugus gravelly loam, severly eroded	42.19	45	B	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	0.00	Open Space - Fair Condition	N/A	39.70	69	2,739.30
Udarents-Aquic	17.53	90	C	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	0.00	Open Space - Fair Condition	N/A	2.31	79	182.44
Hobo silt loam	18.96	35	D	Single Family	Shrub/Scrub	0.00	Single Family Residential	N/A	54.11	91	4,913.19
Hugus gravelly loam, severly eroded	25.06	45	B	Single Family	Shrub/Scrub	0.00	Single Family Residential	N/A	2.71	83	225.75
Hobo silt loam	26.88	35	D	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	28.31	84	2,378.22
Hugus gravelly loam, severly eroded	45.41	45	B	N/A	Barren Land (Rock/Sand/Clay)	0.14	Noncultivated Land	Fair	75.94	69	5,239.86
Slickens	0.00	85	C	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	1.76	79	138.65
Slickens	6.21	85	C	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	14.92	79	1,178.68
Tigley family, gulled	41.46	87	B	N/A	Shrub/Scrub	0.00	Range	Fair	3.96	69	273.16
Total									**315.89**		**25012**
Average	***24.82***									***79.2***	

Soil Name	*% Slope*	*Map #*	*Soil Group*	*Development Classification*	*Existing Cond. Cover Type*	*% Cover*	*Land Use*	*Hydro Cond.*	*Area (ac)*	*CN*	*CN * Area*
NU Gulch											
Hobo-Helmer silt loam, severely eroded	11.20	37	D	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	0.00	Open Space - Fair Condition	N/A	78.48	84	6,592.32
Hugus gravelly loam, severely eroded	13.22	45	B	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	0.00	Open Space - Fair Condition	N/A	2.39	69	164.91
Hobo-Helmer silt loam, severely eroded	9.12	37	D	Single Family	Shrub/Scrub	0.00	Single Family Residential	N/A	21.41	91	1,944.03
Slickens	0.36	85	C	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	2.19	79	172.68
Slickens	1.24	85	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	0.56	91	51.07
Slickens	11.82	85	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	7.27	91	661.65
Slickens	15.15	85	C	N/A	Shrub/Scrub	0.04	Range	Fair	50.05	79	3,953.93
Total									**162.35**		**13541**
Average	***8.87***									***83.4***	
Portal Gulch											
Hobo silt loam	11.67	35	D	Duplex-Triplex	Evergreen Forest	0.00	Multi-Family Residential	N/A	0.34	94	31.93
Hobo-Helmer silt loam, severely eroded	17.87	37	D	Galena Ridge Golf Course	Shrub/Scrub	7.40	Open Space - Fair Condition	N/A	7.53	84	632.52
Hugus gravelly loam, severly eroded	50.08	45	B	Galena Ridge Golf Course	Shrub/Scrub	0.86	Open Space - Fair Condition	N/A	8.06	69	555.94
Hobo silt loam	17.88	35	D	Multi-Family	Shrub/Scrub	48.31	Multi-Family Residential	N/A	7.68	94	718.38
Hobo silt loam	9.02	35	D	Road ROW	Shrub/Scrub	46.75	Impervious Area	N/A	0.74	98	72.21
Hobo silt loam	14.98	35	D	Single Family	Evergreen Forest	52.69	Single Family Residential	N/A	2.85	91	258.66
Hobo silt loam	38.69	35	D	N/A	Shrub/Scrub	0.00	Range	Fair	3.30	84	277.20
Hobo silt loam	34.55	35	D	N/A	Shrub/Scrub	11.08	Range	Fair	3.56	84	299.04
Hobo silt loam	27.54	35	D	N/A	Evergreen Forest	73.95	Woods	Good	6.64	77	511.28
Hobo silt loam	20.25	35	D	N/A	Evergreen Forest	60.18	Woods	Good	4.84	77	373.04
Hobo silt loam	27.87	35	D	N/A	Shrub/Scrub	40.27	Range	Fair	14.24	84	1,196.34
Hugus gravelly loam, severly eroded	46.74	45	B	N/A	Shrub/Scrub	4.61	Range	Fair	8.19	69	565.11
Hugus gravelly loam, severly eroded	56.76	45	B	N/A	Shrub/Scrub	15.50	Range	Fair	4.27	69	294.81
Hugus gravelly loam, severly eroded	46.60	45	B	N/A	Shrub/Scrub	37.93	Range	Fair	33.99	69	2,345.31
Hugus gravelly loam, severly eroded	48.91	45	B	N/A	Shrub/Scrub	18.45	Range	Fair	115.22	69	7,950.18
Udarents-Aquic	3.29	90	C	N/A	Developed, Low Intensity	0.00	Residential	N/A	0.91	90	81.45
Udarents-Aquic	9.26	90	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	11.85	91	1,078.32
Udarents-Aquic	18.44	90	C	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	4.51	79	356.68
Total									**238.73**		**17598**
Average	***27.80***									***73.7***	
Railroad Gulch											
Hobo-Helmer silt loam, severely eroded	18.74	37	D	Galena Ridge Golf Course	Shrub/Scrub	0.21	Open Space - Fair Condition	N/A	73.12	84	6,142.08
Hugus gravelly loam, severly eroded	37.27	45	B	Galena Ridge Golf Course	Shrub/Scrub	23.29	Open Space - Fair Condition	N/A	15.79	69	1,089.85
Udarents-Aquic	11.01	90	C	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	0.00	Open Space - Fair Condition	N/A	7.70	79	608.64
Hobo silt loam	41.67	35	D	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	0.77	84	64.86
Hugus gravelly loam, severly eroded	56.66	45	B	N/A	Shrub/Scrub	15.09	Range	Fair	9.81	69	676.68
Slickens	0.00	85	C	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	4.12	79	325.48
Slickens	0.29	85	C	N/A	Barren Land (Rock/Sand/Clay)	0.00	Noncultivated Land	Fair	1.02	79	80.23
Udarents-Aquic	7.94	90	C	N/A	Developed, Low Intensity	1.03	Residential	N/A	7.39	90	664.68
Udarents-Aquic	6.36	90	C	N/A	Developed, Medium Intensity	0.00	Industrial	N/A	5.17	91	470.54
Total									**124.89**		**10123**
Average	***19.99***									***81.1***	

Curve Number Generation Table for Ultimate Buildout Condition

Soil Name	*% Slope*	*Map #*	*Soil Group*	*Development Classification*	*Existing Cond. Cover Type*	*Land Use*	*Area (ac)*	*CN*	*CN * Area*
Deadwood Lower									
Slickens	3.69	85	C	C-1	Barren Land (Rock/Sand/Clay)	Commercial - Office/Professional	2.11	96	202.10
Udarents-Aquic	8.40	90	C	C-1	Developed, Low Intensity	Commercial - Office/Professional	11.79	96	1,127.51
Hobo silt loam	36.45	35	D	Galena Ridge Golf Course	Shrub/Scrub	Open Space - Fair Condition	28.56	84	2,399.04
Hugus gravelly loam, severly eroded	39.56	45	B	Galena Ridge Golf Course	Shrub/Scrub	Open Space - Fair Condition	34.79	69	2,400.70
Udarents-Aquic	15.73	90	C	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	Open Space - Fair Condition	25.73	79	2,032.72
Hobo silt loam	28.51	35	D	Single Family	Shrub/Scrub	Single Family Residential	4.15	91	376.82
Slickens	0.01	85	C	No Significant Change	Barren Land (Rock/Sand/Clay)	Noncultivated Land	3.64	79	287.56
Slickens	6.15	85	C	R-2	Shrub/Scrub	Residential	3.21	88	283.76
Hobo silt loam	17.52	35	D	Upland Drainages	Shrub/Scrub	Range	0.27	84	23.07
Hugus gravelly loam, severly eroded	48.95	45	B	Upland Drainages	Shrub/Scrub	Range	162.53	69	########
Total							**276.80**		**20348**
Average	***20.50***							***73.5***	
Deadwood Upper									
Honeyjones-Ahrs association	48.16	42	B	Upland Drainages	Evergreen Forest	Woods - Good	450.17	55	########
Latour gravelly silt loam	26.95	60	B	Upland Drainages	Evergreen Forest	Woods - Good	11.30	55	621.59
Tigley family, gulled	65.40	87	B	Upland Drainages	Shrub/Scrub	Range	41.18	69	2,841.55
Total							**502.65**		**28222**
Average	***46.84***							***56.1***	
Gondola Base									
Udarents-Aquic	2.41	90	C	No Significant Change	Developed, Medium Intensity	Industrial	29.78	91	2,709.98
Udarents-Aquic	1.93	90	C	No Significant Change	Paved Area	Paved Area	12.05	98	1,181.36
Total							**41.83**		**3891**
Average	***2.17***							***93.0***	
K1									
Udarents-Aquic	2.11	90	C	No Significant Change	Developed, Low Intensity	Residential	14.18	90	1,276.46
Udarents-Aquic	4.21	90	C	No Significant Change	Paved Area	Paved Area	2.02	98	198.11
Total							**16.20**		**1475**
Average	***3.16***							***91.0***	
K2									
Udarents-Aquic	1.86	90	C	No Significant Change	Developed, Medium Intensity	Industrial	1.85	91	168.08
Total							**1.85**		**168**
Average	***1.86***							***91.0***	
K3									
Udarents-Aquic	2.79	90	C	C-2	Developed, High Intensity	Commercial - General	2.90	98	284.51
Hobo-Helmer silt loam, severely eroded	1.36	37	D	No Significant Change	Developed, Medium Intensity	Industrial	10.92	93	1,015.54
Udarents-Aquic	1.63	90	C	No Significant Change	Developed, Medium Intensity	Industrial	9.50	91	864.44
Total							**23.32**		**2164**
Average	***1.93***							***92.8***	

Soil Name	% Slope	Map #	Soil Group	Development Classification	Existing Cond. Cover Type	Land Use	Area (ac)	CN	CN * Area
K4									
Hobo-Helmer silt loam, severely eroded	12.18	37	D	No Significant Change	Developed, High Intensity	Commercial	2.64	95	250.85
Hobo-Helmer silt loam, severely eroded	8.20	37	D	No Significant Change	Developed, Medium Intensity	Industrial	1.18	93	109.48
Udarents-Aquic	1.97	90	C	No Significant Change	Developed, Medium Intensity	Industrial	35.85	91	3,262.35
Total							**39.67**		**3623**
Average	***7.45***							***91.3***	
Kellogg South									
Udarents-Aquic	4.59	90	C	C-2	Developed, Medium Intensity	Commercial - General	3.17	98	310.58
Hobo silt loam	25.69	35	D	C-2	Shrub/Scrub	Commercial - General	1.60	98	156.80
Hugus gravelly loam, severly eroded	33.76	45	B	C-2	Evergreen Forest	Commercial - General	5.97	98	585.06
Hobo silt loam	16.40	35	D	Duplex-Triplex	Shrub/Scrub	Multi-Family Residential	8.85	94	827.48
Hobo silt loam	20.47	35	D	Hotel Commercial	Shrub/Scrub	Commercial - General	6.12	98	599.28
Hugus gravelly loam, severly eroded	26.09	45	B	Hotel Commercial	Evergreen Forest	Commercial - General	0.47	98	45.76
Lotuspoint, eroded	19.17	64	C	Hotel Commercial	Shrub/Scrub	Commercial - General	1.69	98	165.32
Hobo silt loam	23.46	35	D	Multi-Family	Shrub/Scrub	Multi-Family Residential	12.51	94	1,169.69
Hugus gravelly loam, severly eroded	30.39	45	B	Multi-Family	Shrub/Scrub	Multi-Family Residential	0.50	89	44.80
Hobo silt loam	16.30	35	D	No Significant Change	Developed, Low Intensity	Residential	2.30	92	211.47
Hobo-Helmer silt loam, severely eroded	6.75	37	D	No Significant Change	Developed, Medium Intensity	Industrial	17.73	93	1,648.89
Hugus gravelly loam, severly eroded	30.74	45	B	No Significant Change	Developed, Low Intensity	Residential	10.14	85	861.90
Lotuspoint, eroded	31.23	64	C	No Significant Change	Shrub/Scrub	Range	0.77	79	61.00
Udarents-Aquic	11.06	90	C	No Significant Change	Developed, High Intensity	Commercial	0.32	94	29.74
Udarents-Aquic	9.02	90	C	No Significant Change	Developed, Low Intensity	Residential	2.71	90	243.95
Hobo silt loam	27.45	35	D	R-3	Shrub/Scrub	Multi-Family Residential	2.26	94	211.31
Hugus gravelly loam, severly eroded	39.86	45	B	R-3	Shrub/Scrub	Multi-Family Residential	0.35	89	30.92
Hobo silt loam	30.46	35	D	Road ROW	Shrub/Scrub	Impervious Area	8.49	98	832.02
Hugus gravelly loam, severly eroded	54.09	45	B	Road ROW	Shrub/Scrub	Impervious Area	0.21	98	20.74
Lotuspoint, eroded	24.53	64	C	Road ROW	Shrub/Scrub	Impervious Area	0.37	98	36.26
Hobo silt loam	33.06	35	D	No Significant Change	Shrub/Scrub	Range	45.88	84	3,853.92
Hugus gravelly loam, severly eroded	39.79	45	B	No Significant Change	Shrub/Scrub	Range	13.43	69	926.67
Lotuspoint, eroded	26.42	64	C	No Significant Change	Shrub/Scrub	Range	0.40	79	31.74
Hobo silt loam	19.62	35	D	Single Family	Evergreen Forest	Single Family Residential	10.32	91	937.06
Total							**156.55**		**13842**
Average	***25.02***							***88.4***	
Magnet Gulch									
Hobo silt loam	24.47	35	D	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	Open Space - Fair Condition	92.17	84	7,742.28
Hugus gravelly loam, severly eroded	42.19	45	B	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	Open Space - Fair Condition	39.70	69	2,739.30
Udarents-Aquic	17.53	90	C	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	Open Space - Fair Condition	2.31	79	182.44
Hobo silt loam	18.96	35	D	Single Family	Shrub/Scrub	Single Family Residential	54.11	91	4,913.19
Hugus gravelly loam, severly eroded	25.06	45	B	Single Family	Shrub/Scrub	Single Family Residential	2.71	83	225.75
Slickens	0.00	85	C	No Significant Change	Barren Land (Rock/Sand/Clay)	Noncultivated Land	1.76	79	138.65
Slickens	6.21	85	C	R-2	Barren Land (Rock/Sand/Clay)	Residential	14.92	88	1,318.93
Hobo silt loam	26.88	35	D	Upland Drainages	Barren Land (Rock/Sand/Clay)	Noncultivated Land	28.31	84	2,378.22
Hugus gravelly loam, severly eroded	45.41	45	B	Upland Drainages	Barren Land (Rock/Sand/Clay)	Noncultivated Land	75.94	69	5,239.86
Tigley family, gulled	41.46	87	B	Upland Drainages	Shrub/Scrub	Range	3.96	69	273.16
Total							**315.89**		**25152**
Average	***24.82***							***79.6***	

Soil Name	% Slope	Map #	Soil Group	Development Classification	Existing Cond. Cover Type	Land Use	Area (ac)	CN	CN * Area
NU Gulch									
Hobo-Helmer silt loam, severely eroded	11.20	37	D	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	Open Space - Fair Condition	78.48	84	6,592.32
Hugus gravelly loam, severly eroded	13.22	45	B	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	Open Space - Fair Condition	2.39	69	164.91
Slickens	15.15	85	C	Smelter Closure	Shrub/Scrub	Range	50.05	79	3,953.93
Hobo-Helmer silt loam, severely eroded	9.12	37	D	Single Family	Shrub/Scrub	Single Family Residential	21.41	91	1,944.03
Slickens	1.24	85	C	M-1	Developed, Medium Intensity	Light Industrial	0.56	98	55.00
Slickens	0.36	85	C	No Significant Change	Barren Land (Rock/Sand/Clay)	Noncultivated Land	2.19	79	172.68
Slickens	11.82	85	C	R-2	Developed, Medium Intensity	Residential	7.27	88	642.75
Total							**162.35**		**13526**
Average	***8.87***							***83.3***	
Portal Gulch									
Udarents-Aquic	9.26	90	C	C-2	Developed, Medium Intensity	Commercial - General	11.85	98	1,161.26
Hobo silt loam	27.54	35	D	C-2	Evergreen Forest	Commercial - General	6.64	98	650.72
Hugus gravelly loam, severly eroded	46.60	45	B	C-2	Shrub/Scrub	Commercial - General	33.99	98	3,331.02
Hobo silt loam	11.67	35	D	Duplex-Triplex	Evergreen Forest	Multi-Family Residential	0.34	94	31.93
Hobo-Helmer silt loam, severely eroded	17.87	37	D	Galena Ridge Golf Course	Shrub/Scrub	Open Space - Fair Condition	7.53	84	632.52
Hugus gravelly loam, severly eroded	50.08	45	B	Galena Ridge Golf Course	Shrub/Scrub	Open Space - Fair Condition	8.06	69	555.94
Hobo silt loam	38.69	35	D	M-2	Shrub/Scrub	Industrial	3.30	98	323.40
Hugus gravelly loam, severly eroded	46.74	45	B	M-2	Shrub/Scrub	Industrial	8.19	98	802.62
Udarents-Aquic	18.44	90	C	M-2	Barren Land (Rock/Sand/Clay)	Industrial	4.51	98	442.46
Hobo silt loam	17.88	35	D	Multi-Family	Shrub/Scrub	Multi-Family Residential	7.68	94	718.38
Udarents-Aquic	3.29	90	C	No Significant Change	Developed, Low Intensity	Residential	0.91	90	81.45
Hobo silt loam	34.55	35	D	R-3	Shrub/Scrub	Multi-Family Residential	3.56	94	332.86
Hugus gravelly loam, severly eroded	56.76	45	B	R-3	Shrub/Scrub	Multi-Family Residential	4.27	89	379.20
Hobo silt loam	9.02	35	D	Road ROW	Shrub/Scrub	Impervious Area	0.74	98	72.21
Hobo silt loam	20.25	35	D	No Significant Change	Evergreen Forest	Woods	4.84	79	382.73
Hobo silt loam	14.98	35	D	Single Family	Evergreen Forest	Single Family Residential	2.85	91	258.66
Hobo silt loam	27.87	35	D	Upland Drainages	Shrub/Scrub	Range	14.24	84	1,196.34
Hugus gravelly loam, severly eroded	48.91	45	B	Upland Drainages	Shrub/Scrub	Range	115.22	69	7,950.18
Total							**238.73**		**19304**
Average	***27.80***							***80.9***	
Railroad Gulch									
Slickens	0.29	85	C	C-1	Barren Land (Rock/Sand/Clay)	Commercial - Office/Professional	1.02	96	97.09
Hobo silt loam	41.67	35	D	C-2	Barren Land (Rock/Sand/Clay)	Commercial - General	0.77	98	75.67
Udarents-Aquic	6.36	90	C	C-2	Developed, Medium Intensity	Commercial - General	5.17	98	506.74
Hobo-Helmer silt loam, severely eroded	18.74	37	D	Galena Ridge Golf Course	Shrub/Scrub	Open Space - Fair Condition	73.12	84	6,142.08
Hugus gravelly loam, severly eroded	37.27	45	B	Galena Ridge Golf Course	Shrub/Scrub	Open Space - Fair Condition	15.79	69	1,089.85
Udarents-Aquic	11.01	90	C	Galena Ridge Golf Course	Barren Land (Rock/Sand/Clay)	Open Space - Fair Condition	7.70	79	608.64
Udarents-Aquic	7.94	90	C	M-1	Developed, Low Intensity	Light Industrial	7.39	98	723.77
Slickens	0.00	85	C	No Significant Change	Barren Land (Rock/Sand/Clay)	Noncultivated Land	4.12	79	325.48
Hugus gravelly loam, severly eroded	56.66	45	B	Upland Drainages	Shrub/Scrub	Range	9.81	69	676.68
Total							**124.89**		**10246**
Average	***19.99***							***82.0***	

Soil Name	*% Slope*	*Map #*	*Soil Group*	*Development Classification*	*Existing Cond. Cover Type*	*Land Use*	*Area (ac)*	*CN*	*CN * Area*
CIA & SPA									
Slickens	6.36	85	C	M-1	N/A	Light Industrial	54.25	98	5,316.65
Udarents-Aquic	3.48	90	C	M-1	N/A	Light Industrial	1.83	98	179.12
Slickens	3.86	85	C	R-2	N/A	Residential	128.53	88	########
Udarents-Aquic	0.96	90	C	R-2	N/A	Residential	2.80	88	247.69
Slickens	3.32	85	C	R-3	N/A	Multi-Family Residential	83.20	92	7,654.20
Udarents-Aquic	8.98	90	C	R-3	N/A	Multi-Family Residential	4.94	92	454.65
Total							**275.55**		**25214**
Average	***4.49***							***91.5***	

Bunker Creek Study
Time of Concentration and Lag Time Calculations

Area	Overland Sheet Flow							Shallow Concentrated Flow				
	Manning's n	Length (ft)	Relief (ft)	Slope (ft/ft)	Precip (in)	Travel Time (min)		Length (ft)	Relief (ft)	Slope (ft/ft)	Velocity (ft/sec)	Travel Time (min)
Deadwood Lower	0.4	300	80	0.267	1.8	24.5		1000	50	0.050	3.5	4.8
Deadwood Upper	0.4	300	75	0.250	1.8	25.1		1425	480	0.337	9	2.6
Gondola Base	0.012	300	2	0.007	1.8	6.5		900	2	0.002	1	15.0
K1	0.012	300	10	0.033	1.8	3.4		525	3	0.006	1.2	7.3
K2	0.012	300	3	0.010	1.8	5.5		200	2	0.010	1.7	2.0
K3	0.012	300	15	0.050	1.8	2.9		400	2	0.005	1.2	5.6
K4	0.012	300	5	0.017	1.8	4.5		500	5	0.010	1.7	4.9
Kellogg South	0.4	300	130	0.433	1.8	20.1		3250	960	0.295	8.5	6.4
Magnet Gulch	0.4	300	150	0.500	1.8	19.0		2900	1040	0.359	9	5.4
NU Gulch	0.4	300	70	0.233	1.8	25.8		2925	460	0.157	5	9.8
Portal Gulch	0.4	300	140	0.467	1.8	19.6		1200	540	0.450	10	2.0
Railroad Gulch	0.4	300	200	0.667	1.8	17.0		1550	460	0.297	8.5	3.0
CIA South	0.012	300	5	0.017	1.8	4.5		1815	15	0.008	1.5	20.2
CIA West	0.012	300	5	0.017	1.8	4.5		1350	15	0.011	1.8	12.5

Area	Channel Flow													Total	
	Length (ft)	Relief (ft)	Slope (ft/ft)	Manning's n	Bottom Width (ft)	Side Slope	Depth(ft)	Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius	Velocity (ft/sec)	Travel Time (min)		Time of Conc. (min)	Lag Time (min)
Deadwood Lower	8475	920	0.109	0.04	8	2	0.7	6.58	11.13	0.59	8.62	16.4		45.6	27.4
Deadwood Upper	4950	1450	0.293	0.04	4	2	0.4	1.92	5.79	0.33	9.63	8.6		36.3	21.8
Gondola Base	1900	2	0.001	0.04										21.5	12.9
K1	1100	2	0.002	0.04										10.7	6.4
K2	100	2	0.020	0.04										7.5	4.5
K3	100	2	0.020	0.04										8.4	5.1
K4	1000	2	0.002	0.04										9.4	5.6
Kellogg South	2475	80	0.032	0.04	8	2	0.5	4.5	10.24	0.44	3.86	10.7		37.2	22.3
Magnet Gulch	4850	400	0.082	0.04	4	2	1	6	8.47	0.71	8.48	9.5		33.9	20.4
NU Gulch	1900	140	0.074	0.04	2	2	1	4	6.47	0.62	7.32	4.3		39.9	23.9
Portal Gulch	5625	540	0.096	0.04	3	2	0.5	2	5.24	0.38	6.06	15.5		37.0	22.2
Railroad Gulch	2725	300	0.110	0.04	2	2	0.6	1.92	4.68	0.41	6.80	6.7		26.7	16.0
CIA South	1065	30	0.028	0.04	8	2	0.7	6.58	11.13	0.59	4.39	4.0		28.7	17.2
CIA West	1880	30	0.016	0.04	8	2	0.7	6.58	11.13	0.59	3.31	9.5		26.5	15.9
A to B	1950	10	0.005	0.04	5	2	1.5	12	11.71	1.02	2.70	12.0		12.0	7.2
B to C	700	3.5	0.005	0.04	5	2	1.5	12	11.71	1.02	2.67	4.4		4.4	2.6
C to D	800	4	0.005	0.04	5	2	1.5	12	11.71	1.02	2.67	5.0		5.0	3.0
D to E	1900	9.5	0.005	0.04	5	2	1.5	12	11.71	1.02	2.67	11.9		11.9	7.1
E to F	1500	7	0.005	0.04	5	2	1.5	12	11.71	1.02	2.58	9.7		9.7	5.8
F to G	1300	6	0.005	0.04	5	2	1.5	12	11.71	1.02	2.57	8.4		8.4	5.1

Bunker Creek Study
Routing Parameters Calculations

Reach	Length (1)	Relief (1)	Slope	V (1)	Tt (min)		X	K (hr)		NSTPS	1/2(1-X)	K*60/D*NSTPS	1/2X
A to B	165	1.42	0.008606	6	0.46		0.3	0.01		1	0.35	0.23	1.67
B to C	1085	7.381	0.006803	2.8	6.46		0.3	0.11		3	0.35	1.08	1.67
C to D	1150	5.729	0.004982	3.3	5.81		0.3	0.10		3	0.35	0.97	1.67
D to E	1065	5.768	0.005416	4.8	3.70		0.25	0.06		2	0.375	0.92	2.00
E to F	1440	6.986	0.004851	5	4.80		0.3	0.08		2	0.35	1.20	1.67
F to G	1320	5.859	0.004439	5.9	3.73		0.25	0.06		2	0.375	0.93	2.00
G to H	1800	9.687	0.005382	1.5	20.00		0.3	0.33		10	0.35	1.00	1.67

Note:
(1) Dimension taken from HEC-RAS model developed based on 2007 TerraGraphics survey.

HEC-HMS Output Summary for 2007 Condition

Element	Area (mi^2)	Peak Discharge (cfs)	Time to Peak	Volume (in)
A	0.0615	80.1	01May2007, 12:08	2.9
A TO B	0.0615	78.8	01May2007, 12:12	2.9
B	0.3984	306.2	01May2007, 12:14	2.64
B TO C	0.3984	301.7	01May2007, 12:22	2.64
C	0.7714	500.7	01May2007, 12:24	2.26
C TO D	0.7714	496.3	01May2007, 12:30	2.25
D	0.9664	618.6	01May2007, 12:28	2.28
DEADWOOD LOWER	0.4325	219.3	01May2007, 12:30	1.94
DEADWOOD UPPER	0.786	168.9	01May2007, 12:26	0.86
D TO E	0.9664	614.9	01May2007, 12:30	2.27
E	2.1849	1000.3	01May2007, 12:30	1.7
E TO F	2.1849	974.9	01May2007, 12:42	1.69
F	2.6789	1179.6	01May2007, 12:40	1.79
F TO G	2.6789	1163.4	01May2007, 12:48	1.78
G	2.9329	1265.4	01May2007, 12:48	1.84
GONDOLA BASE	0.065	70.1	01May2007, 12:16	3.01
G to H	2.9329	1244.1	01May2007, 13:08	1.83
K1	0.025	31.1	01May2007, 12:10	2.82
K2	0.0029	3.8	01May2007, 12:08	2.82
K3	0.0365	47.9	01May2007, 12:08	2.91
K4	0.025	32.3	01May2007, 12:08	2.9
KELLOGG SOUTH	0.244	174	01May2007, 12:24	2.46
MAGNET	0.494	336.5	01May2007, 12:24	2.24
NU	0.254	176.5	01May2007, 12:26	2.48
PORTAL	0.373	202.1	01May2007, 12:26	1.86
RAILROAD	0.195	158.2	01May2007, 12:18	2.37

HEC-HMS Output Summary for Design Condition

Element	Area (mi^2)	Peak Discharge (cfs)	Time to Peak	Volume (in)
A	0.0985	127.3	01May2007, 12:08	2.88
A TO B	0.0985	125.3	01May2007, 12:12	2.88
B	0.4354	345.1	01May2007, 12:14	2.61
B TO C	0.4354	337.1	01May2007, 12:20	2.6
C	0.8084	480.4	01May2007, 12:22	2.05
C TO D	0.8084	474.7	01May2007, 12:28	2.04
D	1.0034	580.9	01May2007, 12:26	2.02
DEADWOOD LOWER	0.433	147.9	01May2007, 12:32	1.36
DEADWOOD UPPER	0.786	63.1	01May2007, 12:32	0.48
D TO E	1.0034	576.9	01May2007, 12:30	2.02
E	2.2224	787.4	01May2007, 12:30	1.35
E TO F	2.2224	764.8	01May2007, 12:42	1.34
F	2.7164	929.2	01May2007, 12:40	1.42
F TO G	2.7164	916.1	01May2007, 12:50	1.42
G	2.9704	1002.4	01May2007, 12:48	1.47
GONDOLA BASE	0.065	70.1	01May2007, 12:16	3.01
G to H	2.9704	990.2	01May2007, 12:58	1.47
K1	0.025	31.1	01May2007, 12:10	2.82
K2	0.0029	3.8	01May2007, 12:08	2.82
K3	0.0365	48.4	01May2007, 12:08	2.95
K4	0.062	79	01May2007, 12:08	2.85
KELLOGG SOUTH	0.244	167.6	01May2007, 12:24	2.36
MAGNET	0.494	269.1	01May2007, 12:24	1.79
NU	0.254	151.3	01May2007, 12:26	2.12
PORTAL	0.373	149	01May2007, 12:26	1.41
RAILROAD	0.195	129.9	01May2007, 12:18	1.94

HEC-HMS Output Summary for Ultimate Buildout Condition

Element	Area (mi^2)	Peak Discharge (cfs)	Time to Peak	(in)
A	0.0985	127.9	01May2007, 12:08	2.9
A TO B	0.0985	125.9	01May2007, 12:12	2.9
B	0.4354	355.9	01May2007, 12:14	2.71
B TO C	0.4354	347.6	01May2007, 12:20	2.71
C	0.8084	552	01May2007, 12:22	2.34
CIA_SOUTH	0.215	197.8	01May2007, 12:20	2.85
CIA_WEST	0.215	205.3	01May2007, 12:18	2.85
C TO D	0.8084	545.6	01May2007, 12:28	2.34
D	1.0034	653.8	01May2007, 12:26	2.28
DEADWOOD LOWER	0.433	152	01May2007, 12:32	1.39
DEADWOOD UPPER	0.786	63.1	01May2007, 12:32	0.48
D TO E	1.2184	823.9	01May2007, 12:28	2.37
E	2.4374	1037.7	01May2007, 12:30	1.59
E TO F	2.4374	1009.5	01May2007, 12:42	1.58
F	2.9314	1183.1	01May2007, 12:40	1.62
F TO G	2.9314	1164.8	01May2007, 12:48	1.61
G	3.4004	1315.3	01May2007, 12:46	1.73
GONDOLA BASE	0.065	70.1	01May2007, 12:16	3.01
G to H	3.4004	1292.8	01May2007, 13:06	1.71
K1	0.025	31.1	01May2007, 12:10	2.82
K2	0.0029	3.8	01May2007, 12:08	2.82
K3	0.0365	48.9	01May2007, 12:08	3
K4	0.062	79	01May2007, 12:08	2.85
KELLOGG SOUTH	0.244	179.8	01May2007, 12:24	2.55
MAGNET	0.494	273.8	01May2007, 12:24	1.82
NU	0.254	150.8	01May2007, 12:26	2.11
PORTAL	0.373	209	01May2007, 12:26	1.92
RAILROAD	0.195	134.7	01May2007, 12:18	2.01

HEC-RAS Output Summary Table for Existing, Design and Buildout Conditions

HEC-RAS Plan: 100_TG

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
BC	8210	100yr_2007	80	2278.64	2281.17	2281.17	2281.35	0.005512	4.17	34.05	95.81	0.68		2281.17
BC	8210	100yr_Design	127	2278.64	2281.3	2281.3	2281.52	0.006583	4.89	47.08	101.84	0.76		2281.3
BC	8210	100yr_Buildout	128	2278.64	2281.3	2281.3	2281.52	0.006568	4.89	47.43	102	0.76		2281.3
BC	8074	100yr_2007	80	2277.84	2280.23		2280.25	0.000534	1.48	78.33	96.42	0.23		2280.23
BC	8074	100yr_Design	127	2277.84	2280.36		2280.4	0.000876	2.03	91.74	103	0.3		2280.36
BC	8074	100yr_Buildout	128	2277.84	2280.4		2280.44	0.000791	1.96	95.83	104.92	0.29		2280.4
2	8021	100yr_2007	306	2277.27	2279.84		2280.09	0.005252	4.75	86.12	84.57	0.62		2279.84
2	8021	100yr_Design	345	2277.27	2280.06		2280.27	0.003757	4.28	105.33	85.04	0.53		2280.06
2	8021	100yr_Buildout	356	2277.27	2280.11		2280.31	0.00355	4.21	109.72	85.15	0.52		2280.11
2	7902	100yr_2007	306	2275.68	2279.78		2279.87	0.000669	2.66	138.36	63.9	0.27		2279.78
2	7902	100yr_Design	345	2275.68	2279.98		2280.08	0.000671	2.73	151.52	65.7	0.27		2279.98
2	7902	100yr_Buildout	356	2275.68	2280.03		2280.13	0.000677	2.76	154.66	66.12	0.28		2280.03
2	7748	100yr_2007	306	2275.4	2279.57	2277.92	2279.74	0.00105	3.32	92.1	35.02	0.36		2279.57
2	7748	100yr_Design	345	2275.4	2279.75	2278.07	2279.94	0.001095	3.5	99.32	58.99	0.37		2279.75
2	7748	100yr_Buildout	356	2275.4	2279.79	2278.11	2279.99	0.001112	3.55	102.21	78.65	0.37		2279.79
2	7625		Bridge											
2	7586	100yr_2007	306	2274.02	2277.41		2277.59	0.001866	3.63	107.91	102.71	0.45		2277.41
2	7586	100yr_Design	345	2274.02	2277.39		2277.63	0.002457	4.15	106.21	102.59	0.52		2277.39
2	7586	100yr_Buildout	356	2274.02	2277.51		2277.71	0.002034	3.88	118.61	103.52	0.47		2277.51
2	7409	100yr_2007	306	2272.79	2277.31		2277.4	0.000522	2.56	142.44	71.69	0.27		2277.31
2	7409	100yr_Design	345	2272.79	2277.26		2277.38	0.000698	2.94	138.95	68.65	0.31		2277.26
2	7409	100yr_Buildout	356	2272.79	2277.38		2277.5	0.000658	2.9	147.56	75.93	0.3		2277.38
2	7162	100yr_2007	306	2271.82	2277.3		2277.32	0.000124	1.28	304.27	123.71	0.12		2277.3
2	7162	100yr_Design	345	2271.82	2277.25		2277.28	0.000167	1.48	297.7	123.25	0.14		2277.25
2	7162	100yr_Buildout	356	2271.82	2277.37		2277.4	0.000155	1.45	312.84	124.32	0.13		2277.37
2.5	6990	100yr_2007	501	2270.43	2277.25		2277.29	0.000208	1.74	333.55	139.75	0.15		2277.25
2.5	6990	100yr_Design	480	2270.43	2277.2		2277.24	0.0002	1.69	327.04	139.45	0.14		2277.2
2.5	6990	100yr_Buildout	552	2270.43	2277.31		2277.36	0.000238	1.87	342.2	140.14	0.16		2277.31

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
2.5	6984	100yr_2007	501	2270.43	2277.24		2277.28	0.00021	1.74	332.12	139.68	0.15		2277.24
2.5	6984	100yr_Design	480	2270.43	2277.19		2277.23	0.000202	1.7	325.65	139.39	0.14		2277.19
2.5	6984	100yr_Buildout	552	2270.43	2277.3		2277.35	0.00024	1.88	340.52	140.06	0.16		2277.3
3	6936	100yr_2007	511	2270.34	2277.25		2277.27	0.000086	1.32	521.28	179.37	0.1		2277.25
3	6936	100yr_Design	490	2270.34	2277.2		2277.22	0.000083	1.29	512.88	179.37	0.1		2277.2
3	6936	100yr_Buildout	562	2270.34	2277.31		2277.33	0.000099	1.42	532.41	179.37	0.11		2277.31
3	6782	100yr_2007	511	2269.21	2277.23	2272.8	2277.26	0.000079	1.4	480.8	118.58	0.1		2277.23
3	6782	100yr_Design	490	2269.21	2277.19	2272.76	2277.21	0.000075	1.36	475.33	118.47	0.1		2277.19
3	6782	100yr_Buildout	562	2269.21	2277.29	2272.9	2277.32	0.000092	1.51	487.83	118.72	0.11		2277.29
3	6747		Bridge											
3	6727	100yr_2007	511	2268.57	2277.21	2271.47	2277.24	0.000092	1.46	419.99	133.1	0.1		2277.21
3	6727	100yr_Design	490	2268.57	2277.17	2271.41	2277.2	0.000088	1.42	413.98	132.9	0.1		2277.17
3	6727	100yr_Buildout	562	2268.57	2277.27	2271.61	2277.31	0.000107	1.59	427.5	133.35	0.11		2277.27
3	6700	100yr_2007	511										160.68	2277.21
3	6700	100yr_Design	490										159.35	2277.17
3	6700	100yr_Buildout	562										159.59	2277.27
3	6646	100yr_2007	511	2268.29	2271.73		2272.18	0.004511	5.38	94.94	42.05	0.63		2271.73
3	6646	100yr_Design	490	2268.29	2271.66		2272.1	0.00449	5.31	92.32	41.68	0.63		2271.66
3	6646	100yr_Buildout	562	2268.29	2271.86		2272.35	0.004617	5.58	100.73	42.84	0.64		2271.86
3	6378	100yr_2007	511	2267.06	2270.99		2271.28	0.002339	4.36	120.14	56.05	0.5		2270.99
3	6378	100yr_Design	490	2267.06	2270.91		2271.2	0.002381	4.32	115.94	55.51	0.5		2270.91
3	6378	100yr_Buildout	562	2267.06	2271.08		2271.41	0.002496	4.6	125.5	56.73	0.51		2271.08
4	6327	100yr_2007	619	2266.98	2270.69		2271.12	0.003641	5.26	121.5	58.91	0.61		2270.69
4	6327	100yr_Design	591	2266.98	2270.62		2271.04	0.003648	5.19	117.43	58.18	0.61		2270.62
4	6327	100yr_Buildout	664	2266.98	2270.8		2271.24	0.003623	5.38	127.92	60.01	0.61		2270.8
4	6201	100yr_2007	619	2266.5	2269.97		2270.54	0.005629	6.08	103.01	51.92	0.74		2269.97
4	6201	100yr_Design	591	2266.5	2269.9		2270.46	0.005654	6	99.5	51.32	0.74		2269.9
4	6201	100yr_Buildout	664	2266.5	2270.07		2270.67	0.00559	6.19	108.6	52.86	0.74		2270.07
4	6008	100yr_2007	619	2265.2	2269.18		2269.67	0.003522	5.63	113.76	55.08	0.64		2269.18
4	6008	100yr_Design	591	2265.2	2269.11		2269.58	0.003521	5.54	109.93	53.95	0.64		2269.11
4	6008	100yr_Buildout	664	2265.2	2269.29		2269.8	0.003521	5.75	119.89	56.84	0.64		2269.29

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
4	5835	100yr_2007	619	2264.62	2268.51		2268.99	0.004342	5.58	110.84	53.49	0.68		2268.51
4	5835	100yr_Design	591	2264.62	2268.43		2268.91	0.004342	5.52	107.03	52.76	0.68		2268.43
4	5835	100yr_Buildout	664	2264.62	2268.62		2269.12	0.004325	5.67	117.07	54.64	0.68		2268.62
5	5786	100yr_2007	619	2264.44	2268.39		2268.79	0.003107	5.07	123.23	54.68	0.58		2268.39
5	5786	100yr_Design	591	2264.44	2268.32		2268.7	0.003092	4.99	119.39	53.99	0.58		2268.32
5	5786	100yr_Buildout	664	2264.44	2268.5		2268.92	0.003115	5.18	129.5	55.8	0.58		2268.5
5	5576	100yr_2007	619	2263.72	2267.61	2266.92	2268.04	0.004086	5.27	117.51	54.97	0.63		2267.61
5	5576	100yr_Design	591	2263.72	2267.56	2266.87	2267.97	0.00396	5.15	114.77	54.37	0.62		2267.56
5	5576	100yr_Buildout	664	2263.72	2267.72	2267.01	2268.16	0.004112	5.37	123.71	56.31	0.64		2267.72
5	5419	100yr_2007	619	2263.12	2266.32	2266.24	2267.12	0.008105	7.21	85.89	47.36	0.94		2266.32
5	5419	100yr_Design	591	2263.12	2266.21	2266.18	2267.04	0.008737	7.33	80.68	46.45	0.98		2266.21
5	5419	100yr_Buildout	664	2263.12	2266.42	2266.33	2267.25	0.00801	7.3	90.9	48.22	0.94		2266.42
5	5324	100yr_2007	619	2261.94	2266.24		2266.59	0.002477	4.76	130.61	53.71	0.53		2266.24
5	5324	100yr_Design	591	2261.94	2266.14		2266.49	0.002559	4.75	124.9	52.99	0.54		2266.14
5	5324	100yr_Buildout	664	2261.94	2266.35		2266.72	0.002526	4.9	136.12	54.36	0.54		2266.35
7	5215	100yr_2007	728	2261.6	2265.97		2266.33	0.002405	4.82	154.74	60.32	0.5		2265.97
7	5215	100yr_Design	700	2261.6	2265.84		2266.2	0.002598	4.87	146.74	59.45	0.52		2265.84
7	5215	100yr_Buildout	773	2261.6	2266.08		2266.45	0.002406	4.93	161.18	61	0.51		2266.08
7	5163	100yr_2007	728	2261.52	2265.6		2266.14	0.004407	5.92	124.99	54.6	0.66		2265.6
7	5163	100yr_Design	700	2261.52	2265.39		2265.99	0.005318	6.24	113.49	52.6	0.72		2265.39
7	5163	100yr_Buildout	773	2261.52	2265.7		2266.26	0.004405	6.03	130.58	55.55	0.66		2265.7
7	5137	100yr_2007	728	2261.33	2265.51		2266.03	0.004204	5.74	126.77	55.78	0.67		2265.51
7	5137	100yr_Design	700	2261.33	2265.25		2265.85	0.005345	6.22	112.56	53.22	0.75		2265.25
7	5137	100yr_Buildout	773	2261.33	2265.62		2266.15	0.004174	5.83	132.65	56.74	0.67		2265.62
7	4965	100yr_2007	728	2260.2	2265.18		2265.5	0.001908	4.54	163.06	57.78	0.46		2265.18
7	4965	100yr_Design	700	2260.2	2264.74		2265.15	0.00278	5.11	138.51	54.73	0.55		2264.74
7	4965	100yr_Buildout	773	2260.2	2265.28		2265.61	0.001956	4.66	168.73	58.46	0.47		2265.28
7	4799	100yr_2007	728	2258.8	2265.06		2265.26	0.000852	3.53	206.45	62.63	0.34		2265.06
7	4799	100yr_Design	700	2258.8	2264.57		2264.81	0.001183	3.96	176.72	57.86	0.4		2264.57
7	4799	100yr_Buildout	773	2258.8	2265.16		2265.36	0.000887	3.64	212.4	64.27	0.35		2265.16

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
8	4689	100yr_2007	1109	2259.09	2264.22		2264.99	0.004181	7.03	157.69	57.8	0.75		2264.22
8	4689	100yr_Design	906	2259.09	2263.84		2264.53	0.004114	6.64	136.4	54.96	0.74		2263.84
8	4689	100yr_Buildout	1157	2259.09	2264.3		2265.09	0.004195	7.12	162.46	58.53	0.75		2264.3
8	4545	100yr_2007	1109	2257.98	2263.01	2262.87	2264.09	0.009571	8.32	133.26	53.08	0.93		2263.01
8	4545	100yr_Design	906	2257.98	2262.61	2262.51	2263.62	0.010088	8.03	112.81	49.84	0.94		2262.61
8	4545	100yr_Buildout	1157	2257.98	2263.1	2262.94	2264.19	0.009459	8.38	138.05	53.81	0.92		2263.1
8	4498	100yr_2007	1109	2257.73	2263.02		2263.65	0.00442	6.34	174.89	58.29	0.65		2263.02
8	4498	100yr_Design	906	2257.73	2262.63		2263.18	0.004278	5.95	152.36	55.08	0.63		2262.63
8	4498	100yr_Buildout	1157	2257.73	2263.11		2263.75	0.004443	6.42	180.14	59.02	0.65		2263.11
8	4402	100yr_2007	1109	2257.47	2262.47		2263.23	0.004161	6.99	158.8	57.93	0.74		2262.47
8	4402	100yr_Design	906	2257.47	2262.08		2262.76	0.004187	6.63	136.57	55.2	0.74		2262.08
8	4402	100yr_Buildout	1157	2257.47	2262.56		2263.33	0.004144	7.06	164.02	58.55	0.74		2262.56
8	4184	100yr_2007	1109	2256.28	2261.09		2262.15	0.005655	8.32	138.74	54.66	0.88		2261.09
8	4184	100yr_Design	906	2256.28	2260.71	2260.51	2261.67	0.005761	7.9	118.48	51.66	0.88		2260.71
8	4184	100yr_Buildout	1157	2256.28	2261.17		2262.25	0.00568	8.44	142.95	55.24	0.88		2261.17
8	4126	100yr_2007	1109	2255.62	2260.98	2260.26	2261.76	0.004813	7.21	160.94	53.17	0.69		2260.98
8	4126	100yr_Design	906	2255.62	2260.61		2261.28	0.004603	6.68	141.48	50.99	0.67		2260.61
8	4126	100yr_Buildout	1157	2255.62	2261.06	2260.34	2261.86	0.004897	7.34	164.87	53.6	0.7		2261.06
8	4011	100yr_2007	1109	2255.22	2259.8	2259.8	2261.03	0.007488	9.07	128.18	53.68	0.99		2259.8
8	4011	100yr_Design	906	2255.22	2259.45	2259.45	2260.57	0.007572	8.61	109.83	51.02	0.99		2259.45
8	4011	100yr_Buildout	1157	2255.22	2259.89	2259.89	2261.14	0.007346	9.11	133.22	54.38	0.98		2259.89
8	3910	100yr_2007	1109	2254.08	2259.63		2260.33	0.003176	6.8	170.26	59.11	0.67		2259.63
8	3910	100yr_Design	906	2254.08	2259.18		2259.82	0.00331	6.5	144.36	55.88	0.68		2259.18
8	3910	100yr_Buildout	1157	2254.08	2259.72		2260.44	0.003189	6.9	175.32	59.64	0.67		2259.72
8	3780	100yr_2007	1109	2253.25	2259.37		2259.94	0.002403	6.2	191.65	61.19	0.57		2259.37
8	3780	100yr_Design	906	2253.25	2258.91		2259.42	0.002433	5.85	164.36	58.23	0.57		2258.91
8	3780	100yr_Buildout	1157	2253.25	2259.45		2260.04	0.002437	6.32	196.67	61.64	0.57		2259.45
8	3538	100yr_2007	1109	2252.64	2258.73		2259.27	0.003079	6.04	191.37	58.67	0.56		2258.73
8	3538	100yr_Design	906	2252.64	2258.26		2258.75	0.003141	5.7	164.56	55.65	0.56		2258.26
8	3538	100yr_Buildout	1157	2252.64	2258.79		2259.36	0.003176	6.18	195.09	59.08	0.57		2258.79

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
8	3349	100yr_2007	1109	2252.02	2258.01		2258.61	0.003929	6.24	177.6	54.79	0.61		2258.01
8	3349	100yr_Design	906	2252.02	2257.51		2258.07	0.004107	6	150.98	51.62	0.62		2257.51
8	3349	100yr_Buildout	1157	2252.02	2257.99		2258.66	0.004334	6.55	176.74	54.69	0.64		2257.99
9	3263	100yr_2007	1289	2252.03	2257.12		2258.14	0.006501	8.19	163.94	53.6	0.76		2257.12
9	3263	100yr_Design	1048	2252.03	2256.68		2257.57	0.006849	7.68	140.6	50.77	0.77		2256.68
9	3263	100yr_Buildout	1302	2252.03	2257.15		2258.16	0.006491	8.21	165.12	53.74	0.76		2257.15
9	3095	100yr_2007	1289	2250.38	2256.49		2257.25	0.003731	7.13	192.19	62.46	0.62		2256.49
9	3095	100yr_Design	1048	2250.38	2255.96		2256.66	0.003933	6.76	161.01	56.73	0.63		2255.96
9	3095	100yr_Buildout	1302	2250.38	2256.51		2257.28	0.00373	7.15	193.69	62.72	0.62		2256.51
9	2965	100yr_2007	1289	2249.58	2254.94	2254.86	2256.45	0.009428	10.03	136.05	45.08	0.92		2254.94
9	2965	100yr_Design	1048	2249.58	2254.5	2254.39	2255.83	0.00977	9.38	116.68	42.65	0.91		2254.5
9	2965	100yr_Buildout	1302	2249.58	2254.97	2254.88	2256.48	0.009337	10.04	137.45	45.25	0.91		2254.97
9	2815	100yr_2007	1289	2248.61	2254.84		2255.49	0.00273	6.73	209.97	55.61	0.54		2254.84
9	2815	100yr_Design	1048	2248.61	2254.34		2254.91	0.002659	6.2	183.08	53.06	0.53		2254.34
9	2815	100yr_Buildout	1302	2248.61	2254.88		2255.53	0.002711	6.74	212	55.8	0.54		2254.88
9	2648	100yr_2007	1289	2248.16	2254.12		2254.94	0.003883	7.71	191.14	57.58	0.64		2254.12
9	2648	100yr_Design	1048	2248.16	2253.61		2254.35	0.003988	7.26	162.83	54.27	0.64		2253.61
9	2648	100yr_Buildout	1302	2248.16	2254.18		2254.99	0.00377	7.66	194.62	57.98	0.63		2254.18
9	2448	100yr_2007	1289	2247.19	2253.64		2254.19	0.002886	5.94	220.48	57.76	0.51		2253.64
9	2448	100yr_Design	1048	2247.19	2253.12		2253.6	0.002886	5.53	191.2	54.59	0.5		2253.12
9	2448	100yr_Buildout	1302	2247.19	2253.73		2254.26	0.002765	5.87	225.37	58.27	0.5		2253.73
9	2264	100yr_2007	1289	2246.02	2253.32		2253.74	0.0018	5.36	255.58	59.7	0.42		2253.32
9	2264	100yr_Design	1048	2246.02	2252.81		2253.17	0.001657	4.9	226.22	56.68	0.4		2252.81
9	2264	100yr_Buildout	1302	2246.02	2253.42		2253.83	0.001724	5.3	261.65	60.31	0.41		2253.42
9	2036	100yr_2007	1289	2245.69	2253.06		2253.41	0.001069	4.97	292.62	65.07	0.36		2253.06
9	2036	100yr_Design	1048	2245.69	2252.58		2252.86	0.000956	4.46	262.25	62.33	0.33		2252.58
9	2036	100yr_Buildout	1302	2245.69	2253.17		2253.51	0.001018	4.91	300.09	65.72	0.35		2253.17
10	1973	100yr_2007	1374	2245.74	2252.84		2253.31	0.001731	5.85	271.86	67.13	0.44		2252.84
10	1973	100yr_Design	1121	2245.74	2252.39		2252.78	0.001585	5.31	242.07	64.02	0.41		2252.39
10	1973	100yr_Buildout	1434	2245.74	2252.92		2253.41	0.001788	6	277.21	67.68	0.44		2252.92

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
10	1834	100yr_2007	1374	2244.71	2252.77		2253.08	0.001025	4.6	326.11	69.55	0.34		2252.77
10	1834	100yr_Design	1121	2244.71	2252.33		2252.57	0.000904	4.11	295.5	67.11	0.31		2252.33
10	1834	100yr_Buildout	1434	2244.71	2252.85		2253.17	0.001066	4.73	331.45	69.99	0.34		2252.85
10	1726	100yr_2007	1374	2243.62	2252.63		2252.97	0.000855	5.09	325.01	57.99	0.32		2252.63
10	1726	100yr_Design	1121	2243.62	2252.22		2252.48	0.000699	4.44	301.49	56.32	0.29		2252.22
10	1726	100yr_Buildout	1434	2243.62	2252.7		2253.06	0.000902	5.25	328.85	58.26	0.33		2252.7
11	1652	100yr_2007	1473	2242.83	2252.7		2252.88	0.000532	3.89	501.05	118.15	0.24		2252.7
11	1652	100yr_Design	1220	2242.83	2252.26		2252.41	0.000477	3.54	450.55	111.2	0.23		2252.26
11	1652	100yr_Buildout	1533	2242.83	2252.77		2252.96	0.000551	3.98	509.78	119.3	0.25		2252.77
11	1435	100yr_2007	1473	2242.04	2252.7		2252.78	0.000203	2.72	742.26	149.17	0.16		2252.7
11	1435	100yr_Design	1220	2242.04	2252.25		2252.32	0.000181	2.48	676.08	149.17	0.15		2252.25
11	1435	100yr_Buildout	1533	2242.04	2252.77		2252.86	0.000211	2.78	753.29	149.17	0.16		2252.77
11	1326	100yr_2007	1473	2240.86	2252.7		2252.75	0.000131	2.24	908	176.62	0.13		2252.7
11	1326	100yr_Design	1220	2240.86	2252.25		2252.3	0.000115	2.04	829.57	176.62	0.12		2252.25
11	1326	100yr_Buildout	1533	2240.86	2252.77		2252.83	0.000136	2.29	921.11	176.62	0.13		2252.77
11	1269	100yr_2007	1473	2238.54	2252.69		2252.75	0.000077	2.07	923	144.66	0.11		2252.69
11	1269	100yr_Design	1220	2238.54	2252.25		2252.29	0.000063	1.83	859.11	144.66	0.1		2252.25
11	1269	100yr_Buildout	1533	2238.54	2252.77		2252.82	0.00008	2.13	933.63	144.66	0.11		2252.77
11	1202	100yr_2007	1473	2239.63	2252.67	2244.42	2252.74	0.000103	2.31	760.96	99.23	0.12		2252.67
11	1202	100yr_Design	1220	2239.63	2252.23	2243.99	2252.29	0.000083	2.03	717.81	99.23	0.11		2252.23
11	1202	100yr_Buildout	1533	2239.63	2252.74	2244.52	2252.82	0.000108	2.39	768.06	99.23	0.13		2252.74
11	1150	100yr_2007	1473										160.54	2252.67
11	1150	100yr_Design	1220										177.41	2252.23
11	1150	100yr_Buildout	1533										166.14	2252.74
11	1086	100yr_2007	1473	2239.31	2252.27		2252.32	0.000076	2.12	916.35	124.25	0.11		2252.27
11	1086	100yr_Design	1220	2239.31	2251.71		2251.75	0.000065	1.9	847.28	124.25	0.1		2251.71
11	1086	100yr_Buildout	1533	2239.31	2252.31		2252.37	0.000081	2.2	921.63	124.25	0.11		2252.31
11	966	100yr_2007	1473	2239.02	2252.26		2252.31	0.000057	2.09	1056.57	155.9	0.11		2252.26
11	966	100yr_Design	1220	2239.02	2251.71		2251.75	0.00005	1.89	969.83	155.9	0.1		2251.71
11	966	100yr_Buildout	1533	2239.02	2252.31		2252.36	0.000061	2.16	1063.15	155.9	0.11		2252.31

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
11	803	100yr_2007	1473	2237.98	2252.26		2252.3	0.000056	1.74	1131.51	157.31	0.09		2252.26
11	803	100yr_Design	1220	2237.98	2251.71		2251.73	0.000049	1.57	1043.98	157.31	0.08		2251.71
11	803	100yr_Buildout	1533	2237.98	2252.31		2252.34	0.00006	1.8	1138.11	157.31	0.09		2252.31
11	558	100yr_2007	1473	2238.07	2252.25		2252.28	0.000046	1.64	1125.1	115.01	0.08		2252.25
11	558	100yr_Design	1220	2238.07	2251.7		2251.72	0.000038	1.45	1061.39	115.01	0.07		2251.7
11	558	100yr_Buildout	1533	2238.07	2252.29		2252.33	0.00005	1.7	1129.85	115.01	0.08		2252.29
11	492	100yr_2007	1473	2237.62	2252.26		2252.28	0.000029	1.46	1317.73	140.33	0.07		2252.26
11	492	100yr_Design	1220	2237.62	2251.7		2251.72	0.000024	1.29	1239.89	140.33	0.06		2251.7
11	492	100yr_Buildout	1533	2237.62	2252.3		2252.32	0.000031	1.52	1323.52	140.33	0.07		2252.3
11	439	100yr_2007	1473	2237.02	2252.25	2240.95	2252.28	0.000028	1.42	1312.39	142.49	0.07		2252.25
11	439	100yr_Design	1220	2237.02	2251.7	2240.57	2251.72	0.000023	1.25	1233.39	142.49	0.06		2251.7
11	439	100yr_Buildout	1533	2237.02	2252.3	2241.04	2252.32	0.00003	1.47	1318.27	142.49	0.07		2252.3
11	400	100yr_2007	1473										47.22	2252.25
11	400	100yr_Design	1220										49.41	2251.7
11	400	100yr_Buildout	1533										64.99	2252.3
11	324	100yr_2007	1473	2236.77	2252.23		2252.25	0.00003	1.36	1264.28	125.45	0.07		2252.23
11	324	100yr_Design	1220	2236.77	2251.67		2251.69	0.000024	1.19	1194.51	125.45	0.06		2251.67
11	324	100yr_Buildout	1533	2236.77	2252.25		2252.27	0.000032	1.41	1266.27	125.45	0.07		2252.25
11	275	100yr_2007	1473	2237.03	2252.22	2241.74	2252.25	0.000042	1.69	1060.27	100.54	0.08		2252.22
11	275	100yr_Design	1220	2237.03	2251.66	2241.31	2251.69	0.000034	1.48	1004.7	100.54	0.07		2251.66
11	275	100yr_Buildout	1533	2237.03	2252.23	2241.83	2252.27	0.000046	1.76	1061.77	100.54	0.09		2252.23
11	250	100yr_2007	1473										76.53	2252.22
11	250	100yr_Design	1220										62.25	2251.66
11	250	100yr_Buildout	1533										60.85	2252.23
11	206	100yr_2007	1473	2236.37	2252.16		2252.2	0.00006	1.81	952.47	70.93	0.09		2252.16
11	206	100yr_Design	1220	2236.37	2251.63		2251.66	0.000046	1.56	914.63	70.93	0.07		2251.63
11	206	100yr_Buildout	1533	2236.37	2252.19		2252.24	0.000064	1.88	954.8	70.93	0.09		2252.19
12	194	100yr_2007	1473	2236.37	2252.16	2241.22	2252.2	0.000066	1.92	925.05	68.59	0.09		2252.16
12	194	100yr_Design	1220	2236.37	2251.62	2240.96	2251.66	0.000051	1.65	888.52	68.59	0.08		2251.62
12	194	100yr_Buildout	1533	2236.37	2252.19	2241.29	2252.24	0.000071	2	927.32	68.59	0.09		2252.19
12	125	100yr_2007	1473										473.72	2252.16
12	125	100yr_Design	1220										462.08	2251.62
12	125	100yr_Buildout	1533										473.86	2252.19
12	18	100yr_2007	1473	2235.17	2241	2240.93	2242.71	0.007474	12.15	157.01	40.83	0.92		2241
12	18	100yr_Design	1220	2235.17	2241	2240.51	2242.18	0.005127	10.06	157.01	40.83	0.77		2241
12	18	100yr_Buildout	1533	2235.17	2241.03	2241.03	2242.85	0.007915	12.55	158.21	40.83	0.95		2241.03

HEC-RAS Output Summary Table for Alternative Scenarios

HEC-RAS Profile: 100 yr

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
RR2	102	100 yr	Senario2	105	2266.96	2271.48		2271.5	0.000353	1.36	77.07	26.8	0.14		2271.48
RR2	102	100yr_2007	scenario3	79	2266.96	2271.24		2271.26	0.000256	1.12	70.83	26.27	0.12		2271.24
RR2	87	100 yr	Senario2	105	2266.96	2271.46	2268.92	2271.5	0.000634	1.44	72.84	35.4	0.18		2271.46
RR2	87	100yr_2007	scenario3	79	2266.96	2271.23	2268.68	2271.25	0.000393	1.2	65.73	27.89	0.14		2271.23
RR2	60	100 yr	Senario2	105										49.14	2271.46
RR2	60	100yr_2007	scenario3	79										44.96	2271.23
RR2	27	100 yr	Senario2	105	2265.35	2267.85		2267.91	0.001372	1.93	54.39	35.68	0.28		2267.85
RR2	27	100yr_2007	scenario3	79	2265.35	2268.83		2268.85	0.000154	0.83	95.63	42.6	0.1		2268.83
RR2	14	100 yr	Senario2	105	2264.62	2267.86		2267.89	0.000594	1.38	76.36	38.69	0.17		2267.86
RR2	14	100yr_2007	scenario3	79	2264.62	2268.84		2268.84	0.000092	0.69	114.22	38.69	0.07		2268.84
RR1	109	100 yr	Senario2	1	2268.93	2270.09		2270.09	0.00001	0.11	8.94	11.6	0.02		2270.09
RR1	109	100yr_2007	scenario3	79	2268.93	2272.91		2272.93	0.000329	1.24	63.93	31.94	0.15		2272.91
RR1	92	100 yr	Senario2	1	2267.6	2270.09	2267.75	2270.09	0	0.02	52.27	28.24	0		2270.09
RR1	92	100yr_2007	scenario3	79	2267.6	2272.92	2268.65	2272.93	0.000033	0.52	152.72	49.2	0.05		2272.92
RR1	60	100 yr	Senario2	1										1	2270.09
RR1	60	100yr_2007	scenario3	79										79	2272.92
RR1	24	100 yr	Senario2	1	2267.42	2270.09		2270.09	0	0.02	66.78	35.8	0		2270.09
RR1	24	100yr_2007	scenario3	79	2267.42	2271.18		2271.19	0.000114	1.05	105.88	35.8	0.1		2271.18
Port	125	100 yr	Senario2	86	2274.5	2277.37	2274.94	2277.38	0.000031	0.47	193.68	70	0.05		2277.37
Port	125	100yr_2007	scenario3	202	2274.5	2277.91	2275.25	2277.92	0.000097	0.94	230.97	70	0.09		2277.91
Port	75	100 yr	Senario2	86										39.26	2277.37
Port	75	100yr_2007	scenario3	202										41.16	2277.91
Port	10	100 yr	Senario2	86	2272	2274.25		2274.25	0.000092	0.66	129.81	60	0.08		2274.25
Port	10	100yr_2007	scenario3	202	2272	2275.14		2275.16	0.000167	1.1	183.54	60	0.11		2275.14
NU	42	100 yr	Senario2	96	2248.06	2251.03		2251.11	0.002781	2.27	42.31	36.76	0.37		2251.03
NU	42	100yr_2007	scenario3	177	2248.06	2252.52		2252.56	0.000662	1.73	102.5	43.8	0.2		2252.52
NU	31	100 yr	Senario2	96	2248.06	2251.01		2251.08	0.002261	2	48	39.02	0.32		2251.01
NU	31	100yr_2007	scenario3	177	2248.06	2252.51		2252.55	0.000638	1.6	110.95	44.55	0.18		2252.51
MAGNET	77	100 yr	Senario2	310	2252.7	2256.92		2257.36	0.006825	5.35	57.9	27.26	0.65		2256.92
MAGNET	77	100yr_2007	scenario3	337	2252.7	2258.2		2258.38	0.001902	3.48	96.92	33.72	0.36		2258.2

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
MAGNET	64	100 yr	Senario2	310	2252.7	2256.71	2256.27	2257.25	0.008979	5.91	52.48	26.25	0.74		2256.71
MAGNET	64	100yr_2007	scenario3	337	2252.7	2258.17	2256.37	2258.36	0.001939	3.51	96.09	33.59	0.37		2258.17
MAGNET	````			Bridge											
MAGNET	35	100 yr	Senario2	310	2252.7	2256.69		2256.92	0.003281	3.85	81.11	37.79	0.46		2256.69
MAGNET	35	100yr_2007	scenario3	337	2252.7	2258.22		2258.29	0.000852	2.08	163.65	71.55	0.24		2258.22
MAGNET	20	100 yr	Senario2	310	2252.7	2256.79		2256.84	0.000609	1.8	172.62	66.07	0.2		2256.79
MAGNET	20	100yr_2007	scenario3	337	2252.7	2258.24		2258.27	0.000185	1.23	275.1	73.8	0.11		2258.24
GBASE	625	100 yr	Senario2	1	2277.9	2279.94		2279.94	0	0.03	32.2	22.88	0		2279.94
GBASE	625	100yr_2007	scenario3	70	2277.9	2284.19		2284.19	0.000006	0.31	297.94	72.93	0.02		2284.19
GBASE	529	100 yr	Senario2	1	2278.22	2279.94		2279.94	0	0.02	44.24	49	0		2279.94
GBASE	529	100yr_2007	scenario3	70	2278.22	2284.19		2284.19	0.000004	0.27	343.76	78.34	0.02		2284.19
GBASE	412	100 yr	Senario2	1	2277.61	2279.94		2279.94	0	0.03	38.71	22.28	0		2279.94
GBASE	412	100yr_2007	scenario3	70	2277.61	2284.19		2284.19	0.000006	0.31	318.14	86.74	0.02		2284.19
GBASE	300	100 yr	Senario2	1	2277.73	2279.94		2279.94	0.000001	0.04	23.49	15.39	0.01		2279.94
GBASE	300	100yr_2007	scenario3	70	2277.73	2284.18		2284.19	0.000016	0.45	218.05	81.76	0.04		2284.18
GBASE	201	100 yr	Senario2	1	2277.48	2279.94		2279.94	0	0.04	28.39	18.08	0		2279.94
GBASE	201	100yr_2007	scenario3	70	2277.48	2284.18		2284.18	0.000015	0.39	206.91	67.56	0.04		2284.18
GBASE	135	100 yr	Senario2	1	2277.84	2279.94	2278.22	2279.94	0.000005	0.1	9.93	8.16	0.02		2279.94
GBASE	135	100yr_2007	scenario3	70	2277.84	2284.17	2280.05	2284.18	0.000116	0.92	95.44	74.81	0.09		2284.17
GBASE	100	100 yr	Senario2	1										1	2279.94
GBASE	100	100yr_2007	scenario3	70										13.51	2284.17
GBASE	60	100 yr	Senario2	1	2277.76	2279.92		2279.92	0.000003	0.08	12.71	10.97	0.01		2279.92
GBASE	60	100yr_2007	scenario3	70	2277.76	2280.27		2280.53	0.00699	4.08	18.67	24.43	0.62		2280.27
GBASE	19	100 yr	Senario2	1	2277.82	2279.92		2279.92	0.000002	0.06	16.33	13.54	0.01		2279.92
GBASE	19	100yr_2007	scenario3	70	2277.82	2279.88		2280.19	0.0094	4.44	15.78	13.35	0.72		2279.88
DIVERSION	842	100 yr	Senario2	1	2236.54	2240.06		2240.06	0.000001	0.03	29.07	23.34	0.01		2240.06
DIVERSION	842	100yr_2007	scenario3	1	2236.54	2240.06		2240.06	0.000001	0.03	29.07	23.34	0.01		2240.06
DIVERSION	806	100 yr	Senario2	1	2239.71	2240.03	2240.03	2240.06	0.041938	1.29	0.77	13.23	0.94		2240.03
DIVERSION	806	100yr_2007	scenario3	1	2239.71	2240.03	2240.03	2240.06	0.041938	1.29	0.77	13.23	0.94		2240.03
DIVERSION	631	100 yr	Senario2	1	2238.5	2238.85	2238.7	2238.86	0.002301	0.76	1.31	5.67	0.28		2238.85
DIVERSION	631	100yr_2007	scenario3	1	2238.5	2238.85	2238.7	2238.86	0.002301	0.76	1.31	5.67	0.28		2238.85

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
DIVERSION	327	100 yr	Senario2	1	2237.92	2238.23	2238.09	2238.24	0.001853	0.63	1.58	7.69	0.25		2238.23
DIVERSION	327	100yr_2007	scenario3	1	2237.92	2238.23	2238.09	2238.24	0.001853	0.63	1.58	7.69	0.25		2238.23
DIVERSION	63	100 yr	Senario2	1	2237.13	2237.49	2237.38	2237.5	0.004571	0.9	1.11	6.26	0.38		2237.49
DIVERSION	63	100yr_2007	scenario3	1	2237.13	2237.49	2237.38	2237.5	0.004571	0.9	1.11	6.26	0.38		2237.49
DIVERSION	5	100 yr	Senario2	1	2237.04	2237.28	2237.15	2237.29	0.003001	0.8	1.26	6.14	0.31		2237.28
DIVERSION	5	100yr_2007	scenario3	1	2237.04	2237.28	2237.15	2237.29	0.003001	0.8	1.26	6.14	0.31		2237.28
DEADWOOD	88	100 yr	Senario2	338	2263.56	2265.41	2265.41	2266.09	0.016747	6.61	51.16	38.37	1.01		2265.41
DEADWOOD	88	100yr_2007	scenario3	388	2263.56	2265.55	2265.55	2266.28	0.016312	6.86	56.55	39.26	1.01		2265.55
DEADWOOD	68	100 yr	Senario2	338	2263.38	2265.29	2264.93	2265.71	0.00788	5.2	64.97	39.29	0.71		2265.29
DEADWOOD	68	100yr_2007	scenario3	388	2263.38	2265.44	2265.06	2265.91	0.007923	5.47	70.96	39.94	0.72		2265.44
DEADWOOD	55			Bridge											
DEADWOOD	34	100 yr	Senario2	338	2261.54	2263.15	2263.15	2263.66	0.019627	5.76	58.7	58.01	1.01		2263.15
DEADWOOD	34	100yr_2007	scenario3	388	2261.54	2265.04		2265.1	0.000677	2.01	200.62	82.23	0.22		2265.04
DEADWOOD	19	100 yr	Senario2	338	2260.27	2262.69		2262.93	0.006662	3.95	85.87	64.43	0.6		2262.69
DEADWOOD	19	100yr_2007	scenario3	388	2260.27	2265.05		2265.09	0.000302	1.57	249.41	70.34	0.15		2265.05
CTP	33	100 yr	Senario2	10	2270.64	2274.02		2274.02	0.000017	0.26	38.47	22.84	0.03		2274.02
CTP	33	100yr_2007	scenario3	10	2270.64	2274.95		2274.95	0.000004	0.17	66.87	34.7	0.02		2274.95
CTP	13	100 yr	Senario2	10	2270.4	2274.02		2274.02	0.000005	0.18	64.78	26.1	0.02		2274.02
CTP	13	100yr_2007	scenario3	10	2270.4	2274.95		2274.95	0.000002	0.14	88.85	26.1	0.01		2274.95
CIAWEST	129	100 yr	Senario2	1	2246.84	2248.72		2248.72	0.000001	0.04	23.39	17.04	0.01		2248.72
CIAWEST	129	100yr_2007	scenario3	99	2246.84	2250.46		2250.5	0.000516	1.64	60.31	25.52	0.19		2250.46
CIAWEST	40	100 yr	Senario2	1	2244.71	2248.72		2248.72	0	0.01	91.95	30.36	0		2248.72
CIAWEST	40	100yr_2007	scenario3	99	2244.71	2250.47		2250.48	0.000046	0.67	148.87	35.24	0.06		2250.47
CIAS	28	100 yr	Senario2	1	2263.43	2265.09		2265.09	0.000002	0.05	18.76	19.89	0.01		2265.09
CIAS	28	100yr_2007	scenario3	109	2263.43	2266.36		2266.41	0.001512	1.77	61.59	45.64	0.27		2266.36
CIAS	14	100 yr	Senario2	1	2261.74	2265.09		2265.09	0.000001	0.03	30.56	32.38	0.01		2265.09
CIAS	14	100yr_2007	scenario3	109	2261.74	2266.37		2266.39	0.000647	1.16	93.67	59.84	0.16		2266.37
BC	8210	100 yr	Senario2	285	2278.64	2281.53	2281.53	2281.86	0.005298	5.58	83.4	111.49	0.7		2281.53
BC	8210	100yr_2007	scenario3	80	2278.64	2281.17	2281.17	2281.35	0.005512	4.17	34.05	95.81	0.68		2281.17
BC	8074	100 yr	Senario2	285	2277.82	2280.08	2280.08	2280.47	0.009047	6.17	67.98	89.22	0.95		2280.08
BC	8074	100yr_2007	scenario3	80	2277.84	2280.23		2280.25	0.000534	1.48	78.33	96.42	0.23		2280.23

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
2	8021	100 yr	Senario2	285	2277.27	2279.76		2279.89	0.00179	3.13	112.48	94.46	0.38		2279.76
2	8021	100yr_2007	scenario3	306	2277.27	2279.84		2280.09	0.005252	4.75	86.12	84.57	0.62		2279.84
2	7902	100 yr	Senario2	285	2275.68	2279.67		2279.76	0.000666	2.61	131.22	62.9	0.27		2279.67
2	7902	100yr_2007	scenario3	306	2275.68	2279.78		2279.87	0.000669	2.66	138.36	63.9	0.27		2279.78
2	7748	100 yr	Senario2	285	2275.4	2279.46	2277.83	2279.63	0.001015	3.22	88.57	34.45	0.35		2279.46
2	7748	100yr_2007	scenario3	306	2275.4	2279.57	2277.92	2279.74	0.00105	3.32	92.1	35.02	0.36		2279.57
2	7625			Bridge											
2	7586	100 yr	Senario2	285	2274.02	2276.56	2276.55	2277.19	0.009489	6.42	45.81	37.78	0.98		2276.56
2	7586	100yr_2007	scenario3	306	2274.02	2276.66	2276.66	2277.28	0.008795	6.39	50.06	50.44	0.95		2276.66
2	7409	100 yr	Senario2	285	2272.79	2275.66		2276.05	0.004202	5.25	59.69	41.43	0.71		2275.66
2	7409	100yr_2007	scenario3	306	2272.79	2275.74		2276.15	0.004165	5.34	63.13	42.17	0.71		2275.74
2	7162	100 yr	Senario2	285	2271.82	2274.49		2274.88	0.00538	5.19	58.74	43.74	0.74		2274.49
2	7162	100yr_2007	scenario3	306	2271.82	2275.31		2275.48	0.001568	3.38	97.87	50.6	0.4		2275.31
2.5	6990	100 yr	Senario2	295	2270.43	2274.06		2274.24	0.002208	3.36	87.75	46.09	0.43		2274.06
2.5	6990	100yr_2007	scenario3	501	2270.43	2274.91		2275.14	0.002103	3.89	128.86	51.38	0.43		2274.91
2.5	6984	100 yr	Senario2	295	2270.43	2273.91		2274.11	0.002771	3.65	80.75	44.7	0.48		2273.91
2.5	6984	100yr_2007	scenario3	501	2270.43	2274.76		2275.03	0.002477	4.12	121.64	50.49	0.47		2274.76
3	6936	100 yr	Senario2	295	2270.34	2273.83		2274	0.001655	3.32	91.9	56.27	0.44		2273.83
3	6936	100yr_2007	scenario3	511	2270.34	2274.71		2274.92	0.001477	3.7	148.49	76.73	0.41		2274.71
3	6782	100 yr	Senario2	295	2269.21	2273.75	2272.25	2273.83	0.000612	2.41	143.05	64.36	0.25		2273.75
3	6782	100yr_2007	scenario3	511	2269.21	2274.62	2272.8	2274.74	0.000701	3	202.29	71.25	0.27		2274.62
3	6747			Bridge											
3	6727	100 yr	Senario2	295	2268.57	2271.33		2271.7	0.004612	4.92	59.93	33.29	0.65		2271.33
3	6727	100yr_2007	scenario3	511	2268.57	2272.03		2272.6	0.005111	6.04	84.73	37.13	0.7		2272.03
3	6646	100 yr	Senario2	295	2268.29	2271.05		2271.34	0.003803	4.34	67.93	37.44	0.57		2271.05
3	6646	100yr_2007	scenario3	511	2268.29	2271.73		2272.18	0.004511	5.38	94.94	42.05	0.63		2271.73
3	6378	100 yr	Senario2	295	2267.06	2269.94		2270.25	0.004308	4.5	65.54	47.01	0.67		2269.94
3	6378	100yr_2007	scenario3	511	2267.06	2270.99		2271.28	0.002339	4.36	120.14	56.05	0.5		2270.99
4	6327	100 yr	Senario2	295	2266.98	2269.77		2270.04	0.003649	4.17	71.35	49.15	0.59		2269.77
4	6327	100yr_2007	scenario3	619	2266.98	2270.69		2271.12	0.003641	5.26	121.5	58.91	0.61		2270.69
4	6201	100 yr	Senario2	295	2266.5	2269.03		2269.43	0.00632	5.07	58.17	43.69	0.77		2269.03
4	6201	100yr_2007	scenario3	619	2266.5	2269.97		2270.54	0.005629	6.08	103.01	51.92	0.74		2269.97

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
4	6008	100 yr	Senario2	295	2265.2	2268.25		2268.55	0.003268	4.41	67.48	44.48	0.62		2268.25
4	6008	100yr_2007	scenario3	619	2265.2	2269.18		2269.67	0.003522	5.63	113.76	55.08	0.64		2269.18
4	5835	100 yr	Senario2	295	2264.62	2267.73		2267.99	0.003016	4.07	72.49	45.71	0.57		2267.73
4	5835	100yr_2007	scenario3	619	2264.62	2268.51		2268.99	0.004342	5.58	110.84	53.49	0.68		2268.51
5	5786	100 yr	Senario2	342	2264.44	2267.56		2267.84	0.00308	4.21	81.21	47.24	0.56		2267.56
5	5786	100yr_2007	scenario3	619	2264.44	2268.39		2268.79	0.003107	5.07	123.23	54.68	0.58		2268.39
5	5576	100 yr	Senario2	342	2263.72	2266.82		2267.12	0.003724	4.4	77.73	46.79	0.6		2266.82
5	5576	100yr_2007	scenario3	619	2263.72	2267.61	2266.92	2268.04	0.004086	5.27	117.51	54.97	0.63		2267.61
5	5419	100 yr	Senario2	342	2263.12	2265.57	2265.57	2266.22	0.009009	6.5	52.64	41.04	1.01		2265.57
5	5419	100yr_2007	scenario3	619	2263.12	2266.32	2266.24	2267.12	0.008105	7.21	85.89	47.36	0.94		2266.32
5	5324	100 yr	Senario2	342	2261.94	2265.07		2265.42	0.003829	4.73	72.26	44.91	0.66		2265.07
5	5324	100yr_2007	scenario3	619	2261.94	2266.24		2266.59	0.002477	4.76	130.61	53.71	0.53		2266.24
7	5215	100 yr	Senario2	342	2261.6	2264.81		2265.04	0.002615	3.86	89.12	51.95	0.51		2264.81
7	5215	100yr_2007	scenario3	728	2261.6	2265.97		2266.33	0.002405	4.82	154.74	60.32	0.5		2265.97
7	5163	100 yr	Senario2	342	2261.52	2264.43		2264.83	0.005384	5.07	67.48	43.6	0.72		2264.43
7	5163	100yr_2007	scenario3	728	2261.52	2265.6		2266.14	0.004407	5.92	124.99	54.6	0.66		2265.6
7	5137	100 yr	Senario2	342	2261.33	2264.24		2264.69	0.005922	5.38	63.57	42.89	0.78		2264.24
7	5137	100yr_2007	scenario3	728	2261.33	2265.51		2266.03	0.004204	5.74	126.77	55.78	0.67		2265.51
7	4965	100 yr	Senario2	342	2260.2	2263.16		2263.65	0.006129	5.58	61.33	41.44	0.81		2263.16
7	4965	100yr_2007	scenario3	728	2260.2	2265.18		2265.5	0.001908	4.54	163.06	57.78	0.46		2265.18
7	4799	100 yr	Senario2	342	2258.8	2262.88		2263.1	0.001594	3.75	91.25	43.61	0.46		2262.88
7	4799	100yr_2007	scenario3	728	2258.8	2265.06		2265.26	0.000852	3.53	206.45	62.63	0.34		2265.06
8	4689	100 yr	Senario2	342	2259.09	2262.4		2262.82	0.003924	5.22	65.58	42.04	0.74		2262.4
8	4689	100yr_2007	scenario3	1109	2259.09	2264.22		2264.99	0.004181	7.03	157.69	57.8	0.75		2264.22
8	4545	100 yr	Senario2	342	2257.98	2261.12	2261.12	2261.88	0.011876	6.98	48.99	32.92	1.01		2261.12
8	4545	100yr_2007	scenario3	1109	2257.98	2263.01	2262.87	2264.09	0.009571	8.32	133.26	53.08	0.93		2263.01
8	4498	100 yr	Senario2	342	2257.73	2261.16		2261.44	0.003483	4.25	80.46	43.24	0.55		2261.16
8	4498	100yr_2007	scenario3	1109	2257.73	2263.02		2263.65	0.00442	6.34	174.89	58.29	0.65		2263.02
8	4402	100 yr	Senario2	342	2257.47	2260.68		2261.08	0.00388	5.1	67.01	44.01	0.73		2260.68
8	4402	100yr_2007	scenario3	1109	2257.47	2262.47		2263.23	0.004161	6.99	158.8	57.93	0.74		2262.47
8	4184	100 yr	Senario2	342	2256.28	2259.26	2259.26	2259.94	0.00709	6.59	52.06	38.75	0.99		2259.26
8	4184	100yr_2007	scenario3	1109	2256.28	2261.09		2262.15	0.005655	8.32	138.74	54.66	0.88		2261.09

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
8	4126	100 yr	Senario2	342	2255.62	2259.19		2259.52	0.003874	4.62	75.59	41.45	0.58		2259.19
8	4126	100yr_2007	scenario3	1109	2255.62	2260.98	2260.26	2261.76	0.004813	7.21	160.94	53.17	0.69		2260.98
8	4011	100 yr	Senario2	342	2255.22	2258.19	2258.19	2258.87	0.007585	6.65	52.14	39.33	0.99		2258.19
8	4011	100yr_2007	scenario3	1109	2255.22	2259.8	2259.8	2261.03	0.007488	9.07	128.18	53.68	0.99		2259.8
8	3910	100 yr	Senario2	342	2254.08	2257.69		2258.06	0.003214	4.92	69.67	43.59	0.68		2257.69
8	3910	100yr_2007	scenario3	1109	2254.08	2259.63		2260.33	0.003176	6.8	170.26	59.11	0.67		2259.63
8	3780	100 yr	Senario2	342	2253.25	2257.49		2257.73	0.00169	3.92	89.77	46.52	0.48		2257.49
8	3780	100yr_2007	scenario3	1109	2253.25	2259.37		2259.94	0.002403	6.2	191.65	61.19	0.57		2259.37
8	3538	100 yr	Senario2	342	2252.64	2257.15		2257.31	0.001544	3.26	106.91	48.51	0.37		2257.15
8	3538	100yr_2007	scenario3	1109	2252.64	2258.73		2259.27	0.003078	6.03	191.38	58.67	0.56		2258.73
8	3349	100 yr	Senario2	342	2252.02	2256.94		2257.06	0.00104	2.78	122.82	48.05	0.31		2256.94
8	3349	100yr_2007	scenario3	1109	2252.02	2258.01		2258.61	0.003926	6.24	177.64	54.79	0.61		2258.01
9	3263	100 yr	Senario2	730	2252.03	2255.99		2256.73	0.007425	6.93	107.35	46.12	0.77		2255.99
9	3263	100yr_2007	scenario3	1289	2252.03	2257.13		2258.14	0.00647	8.17	164.2	53.63	0.76		2257.13
9	3095	100 yr	Senario2	730	2250.38	2255.2		2255.77	0.00411	6.08	121.9	46.51	0.64		2255.2
9	3095	100yr_2007	scenario3	1289	2250.38	2256.5	2255.46	2257.26	0.003684	7.1	193.14	62.63	0.62		2256.5
9	2965	100 yr	Senario2	730	2249.58	2253.8	2253.73	2254.9	0.010847	8.44	88.49	38.86	0.93		2253.8
9	2965	100yr_2007	scenario3	1289	2249.58	2254.9	2254.87	2256.44	0.00981	10.16	134.2	44.85	0.93		2254.9
9	2815	100 yr	Senario2	730	2248.61	2253.55		2253.99	0.00262	5.44	142.76	48.99	0.51		2253.55
9	2815	100yr_2007	scenario3	1289	2248.61	2254.78		2255.46	0.002847	6.82	206.87	55.32	0.55		2254.78
9	2648	100 yr	Senario2	730	2248.16	2252.69		2253.38	0.004928	6.9	115.85	47.87	0.69		2252.69
9	2648	100yr_2007	scenario3	1289	2248.16	2253.88		2254.83	0.004733	8.24	177.85	56.05	0.7		2253.88
9	2448	100 yr	Senario2	730	2247.19	2251.82		2252.35	0.004939	5.83	125.21	46.54	0.63		2251.82
9	2448	100yr_2007	scenario3	1289	2247.19	2253.15		2253.86	0.004257	6.74	192.84	54.78	0.61		2253.15
9	2264	100 yr	Senario2	730	2246.02	2251.22		2251.64	0.002803	5.27	143.75	47.17	0.5		2251.22
9	2264	100yr_2007	scenario3	1289	2246.02	2252.57		2253.18	0.002954	6.39	212.97	55.26	0.53		2252.57
9	2036	100 yr	Senario2	730	2245.69	2250.73		2251.1	0.001941	4.96	156.99	51.73	0.45		2250.73
9	2036	100yr_2007	scenario3	1289	2245.69	2252.05		2252.6	0.002076	6.18	230.19	59.3	0.49		2252.05
10	1973	100 yr	Senario2	760	2245.74	2250.09		2250.86	0.006125	7.23	112.88	48.21	0.75		2250.09
10	1973	100yr_2007	scenario3	1374	2245.74	2251.16		2252.32	0.006514	9.05	168.37	55.55	0.81		2251.16
10	1834	100 yr	Senario2	760	2244.71	2248.9	2248.74	2249.84	0.008618	7.87	99.66	45.22	0.89		2248.9
10	1834	100yr_2007	scenario3	1374	2244.71	2250.43		2251.42	0.005845	8.14	177.96	56.88	0.76		2250.43

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Q Culv Group (cfs)	W.S. US. (ft)
10	1726	100 yr	Senario2	760	2243.62	2248.18		2249.05	0.005873	7.74	107.02	40.33	0.76		2248.18
10	1726	100yr_2007	scenario3	1374	2243.62	2249.47		2250.75	0.005899	9.52	162.1	45.14	0.79		2249.47
11	1652	100 yr	Senario2	760	2242.83	2247.77		2248.56	0.006934	7.31	111.16	46.69	0.75		2247.77
11	1652	100yr_2007	scenario3	1473	2242.83	2249.03		2250.26	0.007029	9.32	175.16	54.92	0.8		2249.03
11	1435	100 yr	Senario2	760	2242.04	2246.37		2247.13	0.006193	7.09	113.05	48.95	0.75		2246.37
11	1435	100yr_2007	scenario3	1473	2242.04	2247.6		2248.78	0.00645	9.04	179	58.21	0.79		2247.6
11	1326	100 yr	Senario2	760	2240.86	2245.14	2245.14	2246.2	0.011408	8.3	93	45.63	0.98		2245.14
11	1326	100yr_2007	scenario3	1473	2240.86	2246.36	2246.36	2247.88	0.010074	10.06	154.27	54.68	0.96		2246.36
11	1269	100 yr	Senario2	760	2238.54	2244.93		2245.17	0.000923	3.94	198.46	47.41	0.32		2244.93
11	1269	100yr_2007	scenario3	1473	2238.54	2246.33		2246.82	0.00156	5.69	270.06	54.97	0.43		2246.33
11	1202	100 yr	Senario2	760	2239.63	2244.69		2245.06	0.001986	4.93	157.63	46.6	0.46		2244.69
11	1202	100yr_2007	scenario3	1473	2239.63	2245.91		2246.65	0.003025	6.99	217.51	51.92	0.58		2245.91
11	1086	100 yr	Senario2	760	2239.31	2244.6		2244.85	0.001201	4.25	196.51	62.03	0.38		2244.6
11	1086	100yr_2007	scenario3	1473	2239.31	2245.82		2246.32	0.001721	6	276.1	68.45	0.47		2245.82
11	966	100 yr	Senario2	760	2239.02	2244.44		2244.72	0.001019	4.46	199.51	64.98	0.38		2244.44
11	966	100yr_2007	scenario3	1473	2239.02	2245.55		2246.11	0.001594	6.47	276.52	73.85	0.49		2245.55
11	803	100 yr	Senario2	760	2237.98	2244.26		2244.53	0.00137	4.28	192.78	64.34	0.39		2244.26
11	803	100yr_2007	scenario3	1473	2237.98	2245.22		2245.8	0.002337	6.37	258.51	72.09	0.51		2245.22
11	558	100 yr	Senario2	760	2238.07	2244.42		2244.42	0.000032	0.64	1185.17	276.5	0.05		2244.42
11	558	100yr_2007	scenario3	1473	2238.07	2244.81		2245.25	0.001862	5.86	313.82	192.43	0.46		2244.81
11	492	100 yr	Senario2	760	2237.62	2244.32		2244.41	0.000301	2.55	335.42	75.87	0.2		2244.32
11	492	100yr_2007	scenario3	1473	2237.62	2244.85		2245.11	0.000805	4.43	376.36	79.65	0.32		2244.85
11	439	100 yr	Senario2	760	2237.02	2244.32		2244.39	0.000208	2.37	343.24	66.61	0.17		2244.32
11	439	100yr_2007	scenario3	1473	2237.02	2244.83		2245.07	0.000615	4.2	378.75	72.49	0.29		2244.83
11	324	100 yr	Senario2	760	2236.77	2244.36		2244.37	0.000014	0.51	1495.12	282.18	0.04		2244.36
11	324	100yr_2007	scenario3	1473	2236.77	2244.76		2244.99	0.000732	3.85	382.71	71.42	0.29		2244.76
11	275	100 yr	Senario2	760	2237.03	2244.36		2244.37	0.000015	0.52	1466.13	282.18	0.04		2244.36
11	275	100yr_2007	scenario3	1473	2237.03	2244.56		2244.93	0.001428	4.87	302.42	62.82	0.39		2244.56
11	206	100 yr	Senario2	760	2236.37	2244.3		2244.36	0.000249	2.15	394.95	70.93	0.15		2244.3
11	206	100yr_2007	scenario3	1473	2236.37	2244.6		2244.81	0.000792	3.95	416.51	70.93	0.27		2244.6
12	194	100 yr	Senario2	760	2236.37	2244.29	2240.38	2244.36	0.00026	2.27	385.68	68.59	0.16		2244.29
12	194	100yr_2007	scenario3	1473	2236.37	2244.64	2241.08	2244.78	0.00053	3.31	509.3	88.59	0.22		2244.64
12	125	100 yr	Senario2	760										273.48	2244.29
12	18	100 yr	Senario2	760	2235.17	2242	2239.6	2242.29	0.001001	4.98	197.95	40.83	0.35		2242
12	18	100yr_2007	scenario3	1473	2235.17	2241	2239.94	2241.37	0.002186	6.43	329.21	100.83	0.49		2241

Rational Method for Bunker Creek Study

Watershed	Area (ac)	Rainfall (in/hr)	Soil class	Cover type	Land use	Slope (%)	Runoff coefficient C	Q=CIA (cfs)	Sum
Deadwood Gulch Lower	15.19	1.30	D	shrub/scrub	Range-poor	33.49	0.53	10.47	
Deadwood Gulch Lower	4.49	1.30	D	barren land (rock, sand, clay)	noncultivated land-poor	36.55	0.53	3.09	
Deadwood Gulch Lower	12.97	1.30	D	shrub/scrub	Range-poor	16.77	0.53	8.94	
Deadwood Gulch Lower	9.08	1.30	B	shrub/scrub	Range-poor	62.06	0.53	6.25	
Deadwood Gulch Lower	0.61	1.30	B	Grassland/herbaceous	meadow-poor	41.91	0.55	0.44	
Deadwood Gulch Lower	39.22	1.30	C	barren land (rock, sand, clay)	noncultivated land-poor	13.50	0.53	27.02	
Deadwood Gulch Lower	7.28	1.30	C	barren land (rock, sand, clay)	noncultivated land-poor	2.49	0.49	4.63	
Deadwood Gulch Lower	187.96	1.30	B	shrub/scrub	Range-poor	47.18	0.53	129.50	190.35
Deadwood Gulch Upper	41.18	1.50	B	shrub/scrub	Range-poor	65.23	0.53	32.74	
Deadwood Gulch Upper	0.09	1.50	B	evergreen forest	Woods-poor	56.95	0.53	0.07	
Deadwood Gulch Upper	182.34	1.50	B	evergreen forest	Woods-fair	27.80	0.52	142.22	
Deadwood Gulch Upper	24.25	1.50	B	evergreen forest	Woods-good	48.18	0.52	18.92	
Deadwood Gulch Upper	177.85	1.50	B	evergreen forest	Woods-good	25.93	0.52	138.72	
Deadwood Gulch Upper	11.37	1.50	B	shrub/scrub	Range-fair	23.80	0.53	9.04	
Deadwood Gulch Upper	0.09	1.50	B	shrub/scrub	Range-poor	48.67	0.53	0.07	
Deadwood Gulch Upper	65.65	1.50					0.53	52.19	393.98
Kellogg South	4.24	1.40	D	developed medium intensity	industrial	8.82	0.95	5.64	
Kellogg South	0.32	1.40	C	developed high intensity	commercial	8.62	0.97	0.43	
Kellogg South	0.14	1.40	D	developed medium intensity	industrial	6.84	0.95	0.19	
Kellogg South	13.95	1.40	D	shrub/scrub	range-poor	27.52	0.53	10.35	
Kellogg South	88.29	1.40	D	shrub/scrub	range-poor	23.91	0.53	65.51	
Kellogg South	9.45	1.40	B	shrub/scrub	range-poor	35.48	0.53	7.01	
Kellogg South	16.68	1.40	C	shrub/scrub	range-poor	21.45	0.53	12.37	
Kellogg South	3.06	1.40	B	evergreen forest	woods-poor	44.57	0.55	2.36	
Kellogg South	0.91	1.40	C	developed medium intensity	industrial	6.50	0.95	1.21	
Kellogg South	5.88	1.40	B	shrub/scrub	range-poor	30.96	0.53	4.36	
Kellogg South	13.54	1.40					0.53	10.05	119.48
Magnet Gulch	126.48	1.60	D	shrub/scrub	range-poor	23.66	0.53	107.26	
Magnet Gulch	3.65	1.60	D	shrub/scrub	range-poor	12.93	0.53	3.10	
Magnet Gulch	44.45	1.60	D	shrub/scrub	range-poor	14.57	0.53	37.69	
Magnet Gulch	13.57	1.60	B	barren land (rock, sand, clay)	noncultivated land-poor	32.85	0.53	11.50	
Magnet Gulch	3.96	1.60	B	shrub/scrub	range-poor	40.33	0.53	3.36	
Magnet Gulch	3.27	1.60	B	evergreen forest	woods-fair	46.78	0.52	2.72	
Magnet Gulch	6.37	1.60	C	developed low intensity	resdiential	13.06	0.95	9.69	
Magnet Gulch	12.62	1.60	C	barren land (rock, sand, clay)	noncultivated land-poor	5.50	0.49	9.89	
Magnet Gulch	101.51	1.60	B	barren land (rock, sand, clay)	noncultivated land-poor	43.82	0.53	86.08	271.29

Watershed	Area (ac)	Rainfall (in/hr)	Soil class	Cover type	Land use	Slope (%)	Runoff coefficient C	Q=CIA (cfs)	Sum
Nu Gulch	35.01	1.40	D	shrub/scrub	range-poor	24.85	0.53	25.97	
Nu Gulch	64.89	1.40	D	barren land (rock, sand, clay)	noncultivated land-poor	10.79	0.53	48.15	
Nu Gulch	1.27	1.40	B	barren land (rock, sand, clay)	noncultivated land-poor	12.89	0.53	0.94	
Nu Gulch	60.07	1.40	C	shrub/scrub	range-poor	13.98	0.53	44.57	
Nu Gulch	1.12	1.40	B	barren land (rock, sand, clay)	noncultivated land-poor	24.87	0.53	0.83	120.47
Portal Gulch	7.20	1.40	D	shrub/scrub	range-poor	38.46	0.53	5.34	
Portal Gulch	5.80	1.40	D	shrub/scrub	range-poor	16.59	0.53	4.30	
Portal Gulch	37.84	1.40	D	evergreen forest	woods-fair	24.24	0.52	27.55	
Portal Gulch	1.01	1.40	D	shrub/scrub	range-poor	31.67	0.53	0.75	
Portal Gulch	12.25	1.40	B	shrub/scrub	range-poor	47.70	0.53	9.09	
Portal Gulch	17.27	1.40	C	barren land (rock, sand, clay)	noncultivated land-poor	11.32	0.53	12.81	
Portal Gulch	157.54	1.40	B	shrub/scrub	range-poor	48.60	0.53	116.90	176.74
Railroad Gulch	32.89	1.80	D	shrub/scrub	range-poor	30.00	0.53	31.38	
Railroad Gulch	35.59	1.80	D	shrub/scrub	range-poor	18.37	0.53	33.96	
Railroad Gulch	5.41	1.80	D	shrub/scrub	range-poor	11.57	0.53	5.16	
Railroad Gulch	21.73	1.80	C	barren land (rock, sand, clay)	noncultivated land-poor	8.40	0.53	20.73	
Railroad Gulch	3.66	1.80	C	barren land (rock, sand, clay)	noncultivated land-poor	0.12	0.39	2.57	
Railroad Gulch	25.60	1.80	B	shrub/scrub	range-poor	44.68	0.53	24.42	118.23

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevation** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevation (BFEs) shown on this map apply only landward of 0.0' North American Vertical Datum (NAVD). Users of this FIRM should be aware that coastal flood elevations may also be provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this community. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

The **projection** used in the preparation of this map is Universal Tranverse Mercator (UTM) zone 11. The **horizontal datum** is NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

Spatial Reference System Division
National Geodetic Survey, NOAA
Silver Spring Metro Center
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242,** or visit their website at www.ngs.noaa.gov.

Base map information shown on this FIRM was provided in digital format by U.S. Geological Survey Digital Orthophoto Quadrangles produced at a scale of 1:12000 from photography dated June 22, 1992 or later.

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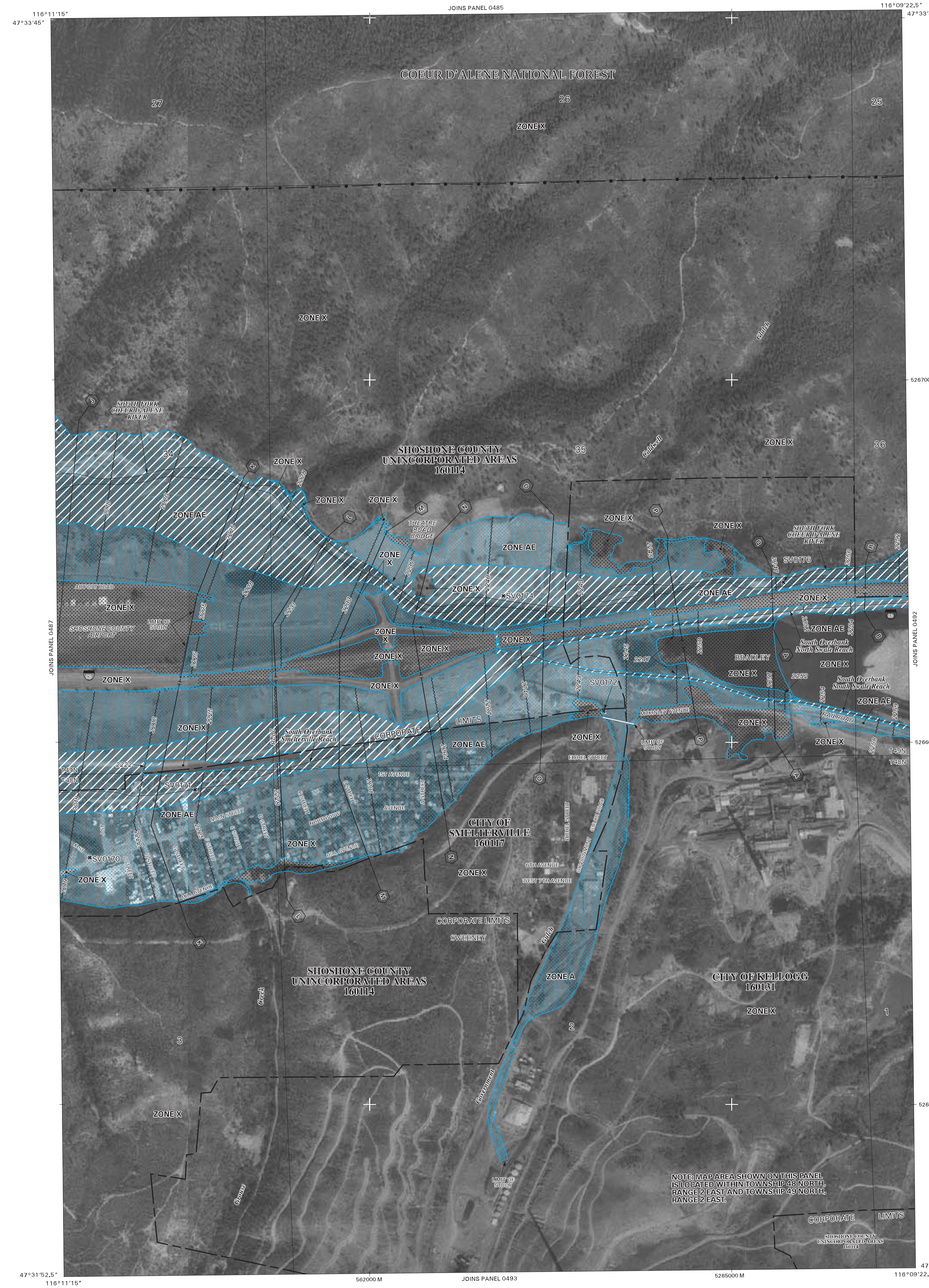
An accompanying Flood Insurance Study report, Letters of Map Revision or Letters of Map Amendment revising portions of this panel, and digital versions of this PANEL may be available. Contact the **FEMA Map Service Center** at the following phone numbers and Internet address for infomation on all related products available from FEMA;

Phone: 800-358-9616
FAX: 800-358-9620
http://msc.fema.gov/

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip/

This map reflects more detailed and up-to-date stream channel configurations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report may reflect stream channel distances that differ from what is shown on this map.



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD EVENT

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood.

ZONE A	No base flood elevations determined.
ZONE AE	Base flood elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Area of special flood hazard formerly protected from the 1% annual chance flood event by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood event.
ZONE A99	Area to be protected from 1% annual chance flood event by a Federal flood protection system under construction; no base flood elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no base flood elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); base flood elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or velocities.
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A	Cross Section Line
23 - - - 23	Transect Line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
4276000M	1000-meter Universal Transverse Mercator grid values, zone 11
600000 FT	5000-foot grid ticks
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel).
• M1.5	River Mile

MAP REPOSITORY
Refer to Repository Listing on Index Map

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

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N

MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0491D

FIRM

FLOOD INSURANCE RATE MAP

SHOSHONE COUNTY,
IDAHO
INCORPORATED AREAS

PANEL 491 OF 1825

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SHOSHONE COUNTY, UNINCORPORATED AREAS	160114	0491	D
KELLOGG, CITY OF	160131	0491	D
SMELTERVILLE, CITY OF	160117	0491	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

U.S. DEPARTMENT OF HOMELAND SECURITY

MAP NUMBER
16079C0491D

EFFECTIVE DATE:

Federal Emergency Management Agency

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevation** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevation (BFEs) shown on this map apply only landward of 0.0′ North American Vertical Datum (NAVD). Users of this FIRM should be aware that coastal flood elevations may also be provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this community. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

The **projection** used in the preparation of this map is Universal Tranverse Mercator (UTM) zone 11. The **horizontal datum** is NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

Spatial Reference System Division
National Geodetic Survey, NOAA
Silver Spring Metro Center
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3242

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NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0492D

FIRM

FLOOD INSURANCE RATE MAP

SHOSHONE COUNTY,
IDAHO
INCORPORATED AREAS

PANEL 492 OF 1825

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

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KELLOGG, CITY OF	160131	0492	D

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16079C0492D

EFFECTIVE DATE:

Federal Emergency Management Agency